E·A·S·E
East-Asian Association for Science Education

EASE2016TOKYO

2016 International Conference of East-Asian Association for Science Education

Innovations in Science Education Research & Practice: Strengthening International Collaboration

E-Proceedings
(Final version:11092016)

Tokyo University of Science
Tokyo, Japan
August 26-28, 2016

東京理科大学
TOKYO UNIVERSITY OF SCIENCE

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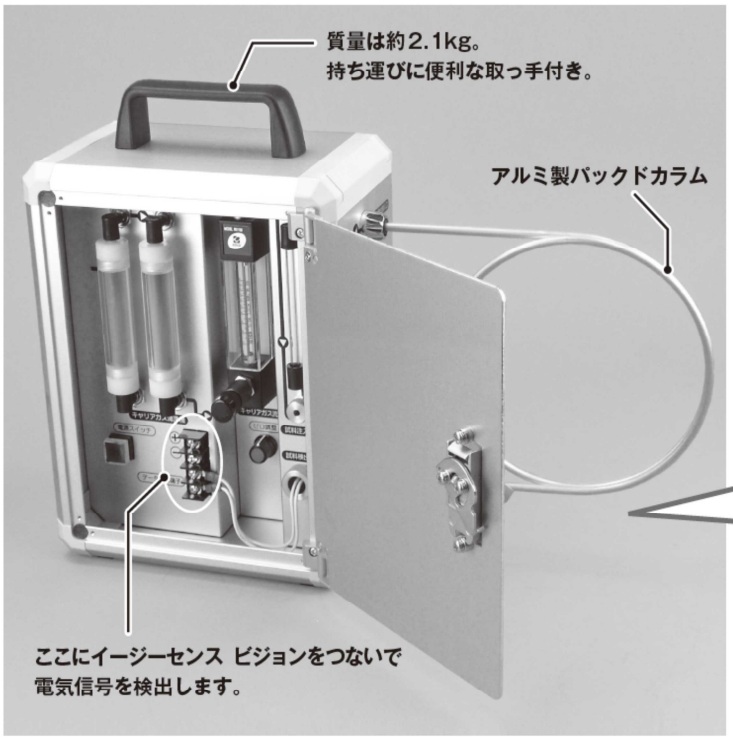

仕様

- 注入口：セプタム（ガスタイトシリンジ使用）
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- 電源：AC100V
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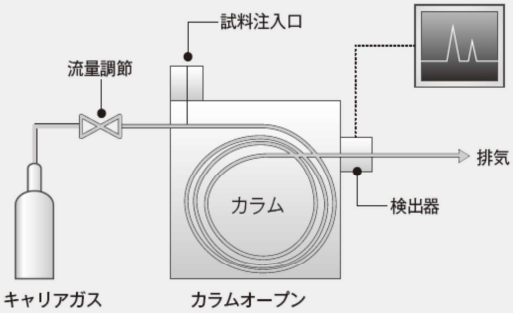

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著：白石範孝　佐々木昭弘　夏坂哲志

- 表現力育成のポイントを，教科の特性との関連で考えた，「アクティブ・ラーニング」推進のための待望のシリーズ第一弾。
- 表現活動は全ての教育活動でも行われ，全ての教科・領域で欠かせない指導である。何をどのように表現していくかという「方法」と「内容」についてのポイントを，板書例，ノート例，作品例などとともに掲載。
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レベルアップ授業力

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幼児の体験活動に見る「科学の芽」

編著：森本　信也（横浜国立大学教授）
磯部　賴子（ベネッセ次世代育成研究所顧問）

- 幼児の体験活動に見られる「科学の芽」を，理科教育（森本）と幼児教育（磯部）のそれぞれの視点で分析。
- 幼稚園教育における様々な実践から科学的思考や知識の「芽生え」を見いだし，価値付け，わかりやすく解説。
- 幼稚園はもちろん，小学校理科，生活科における科学的思考や表現力を育む支援のあり方が見えてくる。

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レベルアップ授業力

言語力の育成を重視した

みんながわかる理科教育法

著：小田切 真（常葉大学教授）・寺本貴啓（國學院大學准教授）

- 小学校理科の新指導要領で重視されている内容について，教材研究の仕方や具体的な指導案を元に解説。
- 理科を久しぶりに担当する先生，苦手意識のある先生，これから教員を目指す学生にも，具体的な事例と語句解説でわかりやすく説明。
- 問題解決学習の解説から，「言語力を重視した理科授業」を意識した評価活動のありかたまで幅広く掲載。更に語句解説や特別支援の視点も交えたコラムなども多数掲載。

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理科指導ガイドブック

「授業力をみがく」シリーズ

本書は新任の先生はもちろん，自分の授業スタイルを振り返ってみたい先生方や研修をご担当の先生にも参考にしていただける内容となっております。

小学校 理科

「授業力をみがく」
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「観察・実験の進め方」「薬品や器具の安全な使い方」を取り上げ，具体的な事例について解説。また，付録 CD-ROM には，実際に作業している動画を収録。

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中学校 理科

「授業力をみがく」
指導ガイドブック

指導上の要点やスキルを実践的に取り上げ，中学校理科についての疑問や誤解を解消する内容を掲載。巻末「理科に関する教育用語」，付録「サイエンスカレンダー」

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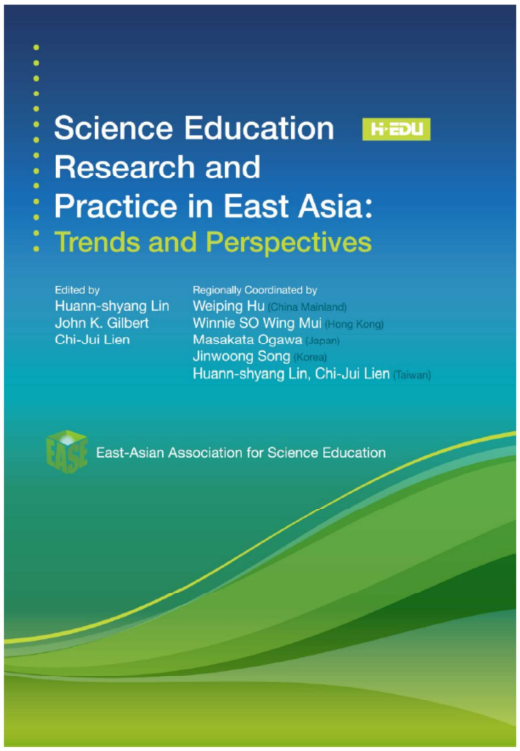

Need to know science education in East Asia?

The East-Asian Association for Science Education (EASE) initiated the BOOK Project for systematically revealing the research and practice in this thriving region. This book thus invited more than 50 science educators working cross-regionally on 15 important themes to meet science educators' needs.

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TILL: The closing day of the 2016 Conference (the end of the August).

Edition: The 2016 EASE Conference Edition. (Can be mailed and sold to the East-Asian region only.)

For Conference authors/participants from other regions, please send your request to easebook2016@gmail.com for special assistance.

EASE Alumni Events in EASE 2016 Tokyo

EASE Conference Tour & Exchange for Graduate Students

The purpose of EASE Conference Tour & Exchange is to support mainly graduate students. For students who participate in an international conference for the first time, they might feel nervous and get worried. EASE Alumni will go around with them in this conference and support their participation. For experienced students, let's exchange your know-how and information with us! We hope that you join the EASE Alumni events! We are waiting for you at Room 845!

Date : 26-28 August
Time: 1) 8:00-10:30
2) 10:30-12:30
Venue: Building No. 8, 4th Floor, Room 845

We are **EASE Alumni!**

EASE Alumni means mainly for the doctoral students and master students around East-Asia regions who have taken parts in either Summer School or Winter School Programs convening by EASE.

For more information contact: TAKAHASHI Kazumasa
E-mail: takahashi.kazumasa@a.hokkyodai.ac.jp

TABLE OF CONTENTS

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OVERVIEW OF EASE2016TOKYO

Theme

Innovations in Science Education Research & Practice: Strengthening International Collaboration

Conference Dates

August 26 – 28, 2016

Venue

Tokyo University of Science (Kagurazaka Campus), Shinjuku, Tokyo, Japan

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WELCOME MESSAGE

Dear Colleagues & EASE friends

It is our great pleasure to invite science educators and scientists, as well as EASE members to the EASE 2016 Tokyo Conference. The Conference, co-organized by the Tokyo University of Science, will be held at the Tokyo University of Science, Kagurazaka campus, on August 26 (Fri) to August 28 (Sun), 2016, with arrangement of registration, an ice breaking meeting, and an informal meeting of grad students and mentors on the 25 (Thu) afternoon.

This is the fifth EASE International Conference and the last one of the first round of the conferences for the decade. This means that we are going into the second round and the second decade. We need to make a difference, and we need something new. From this point of view, apart from our ordinary style and format of the EASE International Conferences, we do strongly encourage junior scholars (including graduate students) to commit the EASE. Especially, we expected the alumni group of the EASE summer or winter schools to take initiatives to do 'something new,' in order to strengthen their networking and collaboration for the future. Please encourage your students to come to the Conference, so that cross-regional exchange among the junior scholar group will be much visible.

We are very looking forward to seeing you all at TUS!!

Sincerely

Masakata Ogawa （小川正賢）
Chair of the Organizing Committee
Yoshisuke Kumano（熊野善介）
Vice-Chair of the Organizing Committee
Kazuo Kitahara（北原和夫）
Vice-Chair of the Organizing Committee

WELCOME MESSAGE

Dear Colleagues and Guests,

I am glad to see the successful launch of the fifth biennial EASE conference in Tokyo, Japan. With this conference, all five regions of EASE have now each hosted a conference. All of us at EASE share a common goal, that is to maintain and use it as a platform for science education researchers/teachers, on which we can share recent findings and solutions, and more importantly, to set out on a quest and exploration of science education. Through the various activities organized by EASE, we hope to encourage the cross-fertilisation of ideas, and facilitate research at the forefront of science education.

We may well be celebrating our 10th anniversary at EASE in 2017. Looking back, EASE has taken huge steps since its establishment under the leadership of the four presidents. We have published 34 editions of the EASE newsletter for which we have received contributions from colleagues, teachers, and students, and through which we have shared news and updates of research and activities. Both summer and winter schools for graduates have been organized to provide opportunities to learn from each other, reflect on individual progress, and generate friendships. We are happy to see the launch of the edited book led by Professor Lien Chi-jui, evidence of the collegiality and quality work at EASE. This publication marks our EASE colleagues' pursuit of excellence in the learning and teaching of science, our sincere quest for knowledge, and our contribution to the advancement of science education research. Last but not least, the biennial conferences are a highlight of the EASE achievements.

Here, I would like to thank the Chair of the Organising Committee of this conference, Professor Ogawa, and all the colleagues in Japan who have worked hard in the last year to prepare for this event. My thanks also go to the Executive Members of EASE who have worked with me and Dr Peter Wan at the Hong Kong Headquarters to steer the development of EASE during the past eight months.

I wish you all a very successful conference and a most memorable experience in Tokyo.

May Cheng

CHENG May Hung, May (鄭美紅), Ph.D.
President, East-Asian Association for Science Education
Associate Vice-president cum Registrar,
Chair Professor of Teacher Education,
Department of Curriculum and Instruction
The Education University of Hong Kong

PROGRAM SUMMARY

	Time	Activities	Rooms
25th (Thu)	13:00-15:00	Preparations	All Rooms
	15:00-18:00	Registration	Room624
	15:00-18:00	Ice Breaking	Breakroom 1
		SIG Meetings	Rooms A to L
		EASE Grad Students' Meeting	Room 845
		EASE Headquarter Meeting	Room 844
	18:00-20:00	EASE EMs Meeting	Room 844
26th (Fri)	08:30 -	Registration	Room 624
	09:00-09:40	Opening	Room A Live Remote (B, C, D, E & Breakroom 1)
	09:40-10:20	Plenary 1	
	10:20-11:00	Plenary 2	
	11:00-11:30	Refreshment	Breakrooms 1, 2, & Lobbies
	11:30-12:50	Oral 1 (4 papers), Poster 1, Special Poster 1	Oral (Rooms A to L), Poster (Rooms X & Y)
	12:50-13:30	Lunch ('Asia Pacific Science Education' Reception)	All Rooms (Reception, Breakroom 2)
	13:30-14:10	Keynotes 1 (Room A) & 2 (Room B)	Room A, Live Remote (C & Breakroom 1)
	14:10-14:50	Keynotes 3 (Room A) & 4 (Room B)	Room B, Live Remote (D & E)
	14:50-15:00	Break	
	15:00-16:00	Oral 2 (3 papers)	Rooms A to L
	16:00-16:30	Refreshment	Breakrooms 1, 2, & Lobbies
	16:30-18:30	Symposia 1, Workshops 1, Demonstrations 1	Rooms A to L & X
27th (Sat)	08:30 -	Registration	Room 624
	09:00-11:00	Oral 3 (6 papers)	Rooms A to L
	11:00-11:30	Refreshment	Breakrooms 1, 2, & Lobbies
	11:30-12:50	Oral 4 (4 papers), Poster 2, Special Poster 2	Oral (Rooms A to L), Poster (Rooms X & Y)
	12:50-13:30	Lunch	All Rooms
	13:30-14:10	Keynotes 5 (Room A) & 6 (Room B)	Room A, Live Remote (C & Breakroom 1)
	14:10-14:50	Keynotes 7 (Room A) & 8 (Room B)	Room B, Live Remote (D & E)
	14:50-15:00	Break	
	15:00-16:00	General Assembly	Room A, Live Remote (B, C, D, E, & Breakroom 1)
	16:00-16:30	Refreshment	Breakrooms 1, 2, & Lobbies
	16:30-18:30	Symposia 2, Workshops 2, Demonstrations 2	Rooms A to L & X
	19:00-21:00	Banquet (Pre-Registered)	Agnes Hotel & Apartments Tokyo
28th (Sun)	08:30 -	Registration	Room 624
	09:00-11:00	Oral 5 (6 papers)	Rooms A to L
	11:00-11:30	Refreshment	Breakrooms 1, 2, & Lobbies
	11:30-12:50	Oral 6 (4 papers), Poster 3, Special Poster 3	Oral (Rooms A to L), Poster (Rooms X & Y)
	12:50-13:30	Lunch	All Rooms
	13:30-14:50	Oral 7 (4 papers)	Rooms A to L
	14:50-15:00	Break	
	15:00-16:00	Awards & Closing	Room A

VENUE

Tokyo University of Science, 'Kagurazaka Campus' (Bldg. Nos. 2, 6, & 8)
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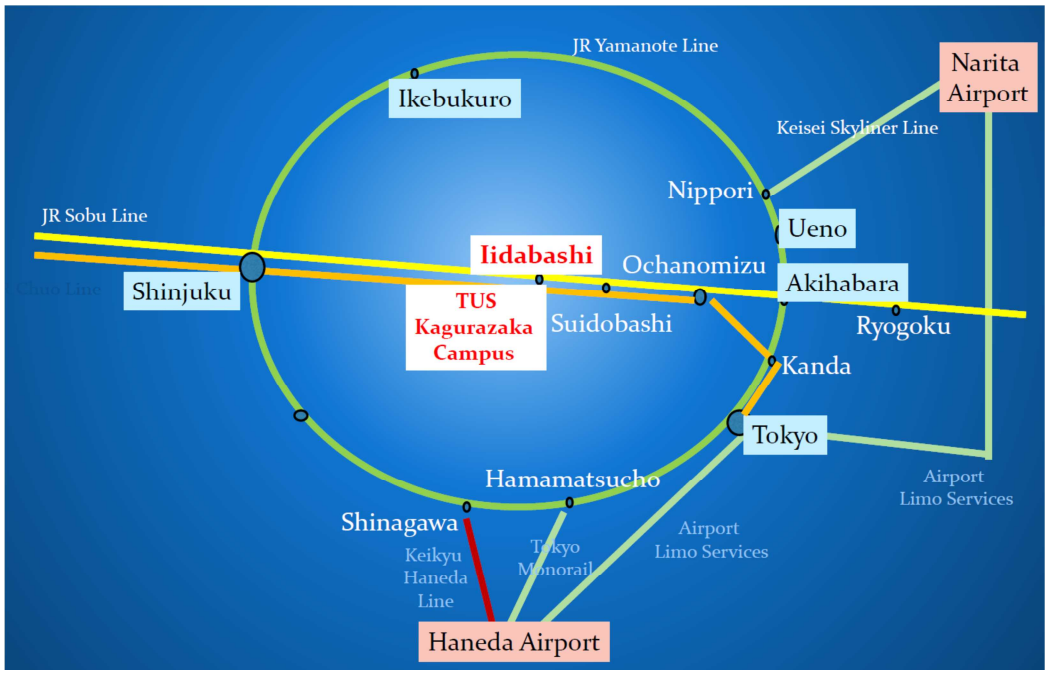
TRANSPORTATION



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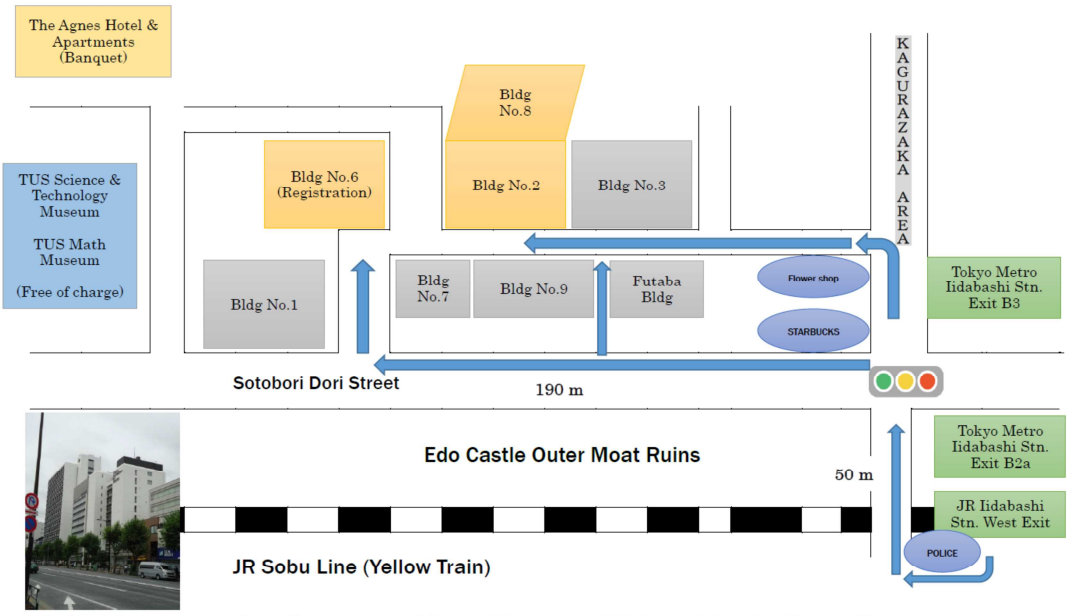
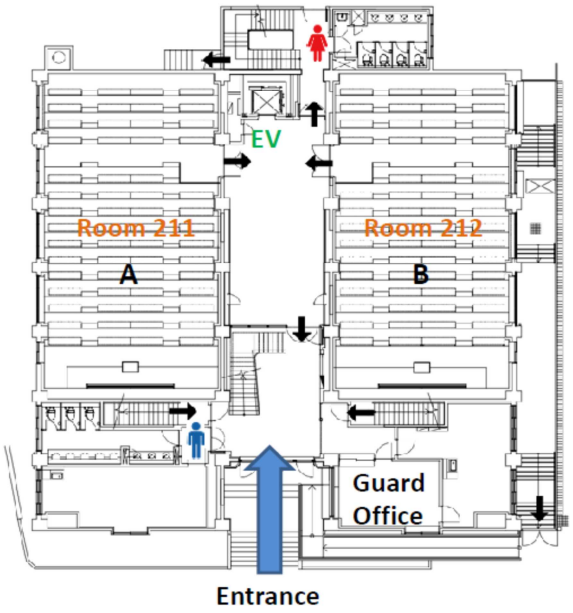
CAMPUS MAP



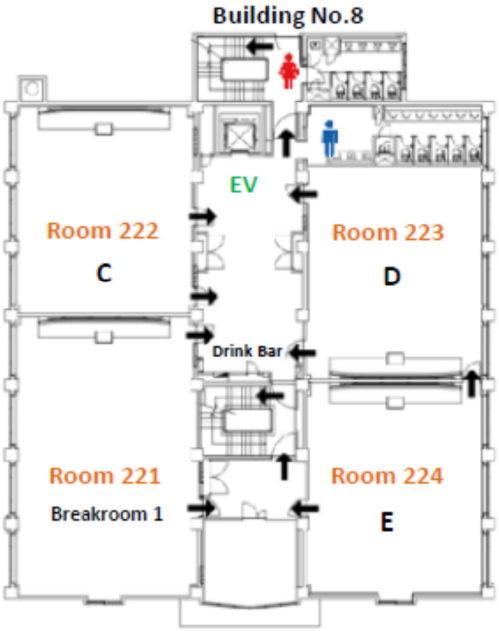
TUS Kagurazaka Campus Map (Venue: Bldgs. No.2, 6, & 8)

FLOOR PLANS

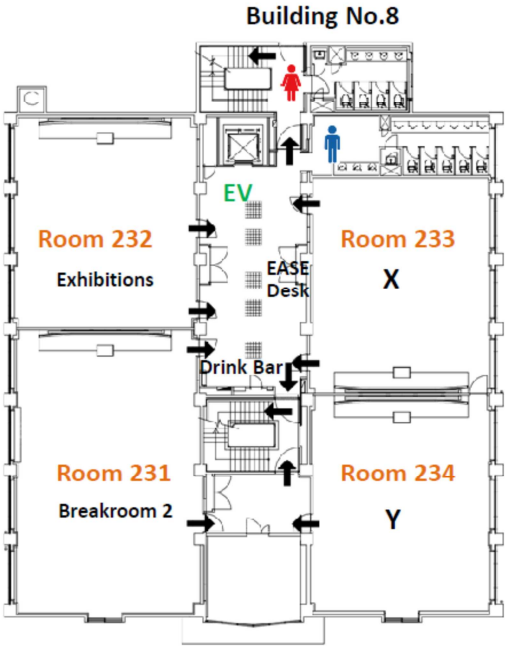
Building No.2 : 1st Floor



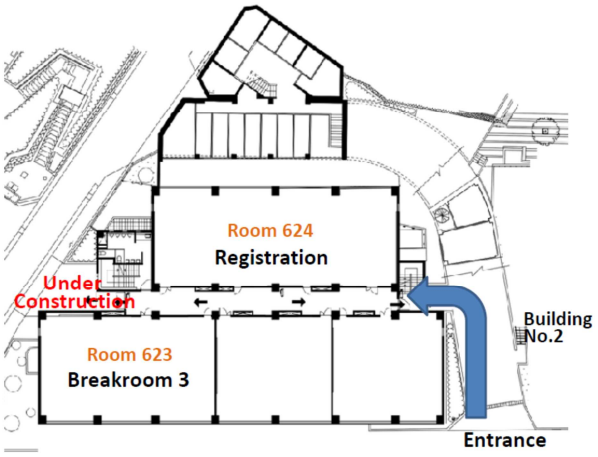
Building No.2 : 2nd Floor



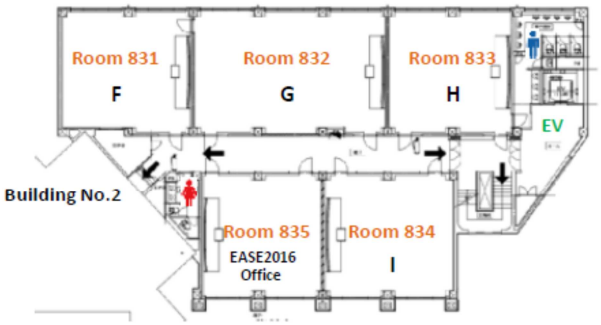
Building No.2 : 3rd Floor



Building No.6 : 2nd Floor



Building No.8 : 3rd Floor



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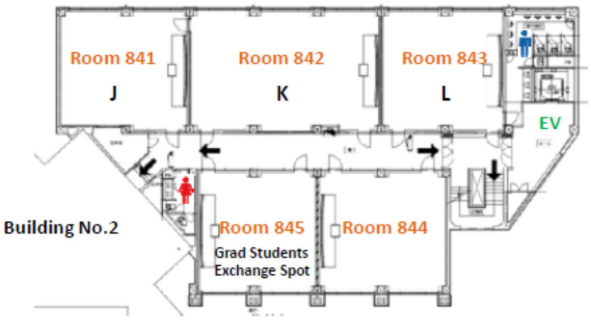


GUIDELINES

Strands

1. Studies on Learners:
2. Studies on Teachers:
3. Studies on Interactions between Teaching and Learning:
4. Curriculum/Assessment/Policy:
5. Curriculum/Teaching Materials:
6. ICT in Science Education:
7. Integrated Sciences (SSI, EE, ESD):
8. Teacher Education:
9. STEM Education:
10. Historical, Philosophical, Sociological, Cultural and Gender Issues:
11. Science Education in Informal Settings:
12. Science Communication/Engagement:
13. Mathematics Education: and
14. Other Issues.

Oral Presentation

20 minutes, including 4-5 minutes for questions and discussion.
An LCD projector (connected with a VGA or Mini Display Port) is provided.
Neither computers nor tablets are available. Please bring your own machine with you (Caution: 100V, 50Hz, Type A plug).
Since no technical staff is available, please do it by yourself. You can check it in the afternoon of the 25th.
It is recommended to prepare A4-sized handouts of the presentation.

RGB cable with mini stereo pin

Mini DisplayPort to VGA conversion cable

(Session Chairpersons)

Since there are 12 concurrent sessions simultaneously running in each oral presentation slot, it is very difficult to invite chairpersons from other sessions. At the same time, there are three sessions simultaneously running with the poster session. Therefore, we decided to assign one (or two in the session consisting of more than 5 presentations) of the presenters (or authors) within each session to the session chairpersons. However, it sometimes happens that the presenter(s) cancel the presentation with unavoidable or unexpected reasons after the conference program had been announced. If such case happens, we appreciate someone else in the session to take on the chairperson's role.

Poster & Special Poster Presentation

A0-sized (841mm (width) x 1189mm (height)) posters must be prepared.
Pins are prepared by the EASE2016. Tapes, and glue stick are prohibited.
In front of the panel, a table space (450mm (width) x 900mm (length)) is provided.
The authors should post their posters 10 minutes before the session.

Posters will be presented during the designated poster session.
Presenters should stay during the assigned session to discuss their work with participants.
It is recommended to prepare A4-sized handouts of the presentation.

Symposium

Symposium should be limited to 2 hours, including presentations, discussion, and questions.
The organizer will manage the session.
An LCD projector (connected with a VGA or Mini Display Port) is provided.
Neither computers nor tablets are available. Please bring your own machine with you.
A symposium should involve 2-3 experts or stakeholders to deepen the discussion.
It is recommended to prepare A4-sized handouts of the presentation.

Workshop

Each workshop should run from 60 - 120 minutes.
The presenter(s) must announce the total time of the workshop to the audience before starting.
An LCD projector (connected with a VGA or Mini Display Port) is provided (see Oral Presentation).
Neither computers nor tablets are available. Please bring your own machine with you.
It is recommended to prepare a set of rich materials for the workshop audience.

Demonstration

The demonstration should be limited to 60 -120 minutes.
The demonstration should involve experiments/exhibitions relevant to science or science teaching.
A0-sized (841 mm (width) x 1189 mm (height)) illustrations are recommended.
The location of each demonstration will be assigned on site.

INFORMATION & REMINDERS

Registration Room, Help Desk, and Special Rooms

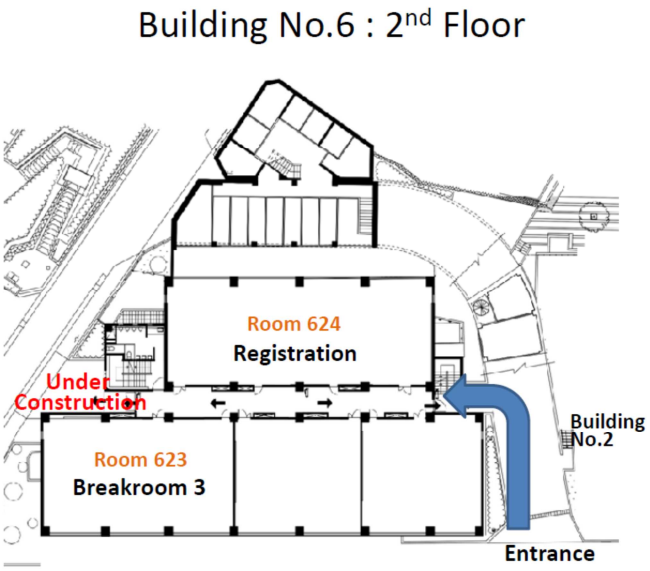
	Room	Open Time & Explanation	
Registration Room	Room 624	25th, 15:00 – 18:00 26th, 08:30 – 16:00 27th, 08:30 – 16:00 28th, 08:30 – 12:00	Categories Pre-registrants [R0XXX] On-site Registrants (Cash) One Day Registrants (Cash)
Breakrooms	Rooms 221 & 231 with Drink Bars Room 623 without Drink Bar	26th – 27th, 08:30 – 18:00; 28th 08:30 – 15:00 Room 221 is unavailable during the live remote sessions (26th, 9:00-11:00, 13:30-14:50. 27th, 13:30-16:00).	
Help Desk (Non-Academic)	Lobby (1st Floor, Bldg. No.2)	26th – 28th, 09:00 – 16:00 (Chinese, Korean Students and High School Students' Volunteers)	
EASE2016 Office (Academic)	Room 835	Academic matters. Sorry, we cannot offer printing service. (handouts, etc.) Avail this service in convenience stores near-by.	
EASE HQ Desk	Lobby (3rd Floor, Bldg. No.2)	EASE Membership	
Grad Students' Exchange Spot	Room 845	26th – 27th, 08:30 – 18:00; 28th, 08:30 – 15:00 (Managed by EASE Alumni & Mentors) "Melting" Spot of EASE Mentors & Grad Students (New Comers)	

Registration Booth

Pre-registrants are identified only by the registration number ([R0XXX]). We cannot check your status with your name, region, affiliation, nor the abstract number ([A0XXX]). You can go directly to the appropriate booth led by your registration number.

Pre-registrants with credit card problems need to go to the special booth, not to go to the pre-registrants' regular booth.

On-site registrants (by cash only) should go to the on-site booth. No credit card is acceptable.



Name Tag, Official Receipt, Conference Certificate etc.

All necessary materials (Name Tag, Official Receipt of Registration Fee (Banquet Fee), the Official Certificate of Participation, Lunch Coupons, Instruction Sheet, and Conference Bag Ticket) are printed on one sheet.

Lunch Box and Lunch Venues

Lunch box tables are open every day from 12:30 around the Breakrooms, 221 and 231. Lunch ticket on designated day is needed. Vegetarian and Halal lunches are for pre-registered participants (identified on the lunch ticket) only. You can enjoy lunch at any conference rooms including breakrooms, if the sessions are closed.
[CAUTION] Conference participants are not allowed to go into the canteens (1st and 2nd Floors in Bldg. No.8).

Free Refreshment

Refreshment service is available at 11:00 and 16:00 at the drink bar areas, every day (except 16:00 on the last day).

Photos

Just as in our previous EASE conference, we will invite a photo team (TUS photo circle members) to take snapshots of 'what are going on' and the pictures will be uploaded to the Flickr site, which is shown in the instruction sheet, attached to the name tag, every day. You can enjoy the scenes you miss on the site, and even download them. We believe that all of the participants accept to be photographed and uploaded on the Flickr site (which is not open to the public, but to the participants who know the particular Flickr site shown in the instruction sheet alone). However, if you find a picture you are not willing to show on the site, please send an email to ee2016tokyo.photo@gmail.com , identifying the photo number and asking the photo team to take down, so that they will delete them as soon as possible.

Internet Connection

Internet connection during the conference is available by SSID and Key shown in the instruction sheet.

Conference Banquet

Conference banquet is only for pre-registered participants. We are so sorry that no on-site requests are accepted.

The banquet on 27th at the Agnes Hotel & Apartments Tokyo starts at 19:00, but the welcome drink service starts at 18:30. The hotel is 5 min walk from the conference venue.

Venue: The Agnes Hotel and Apartments Tokyo
http://www.agneshotel.com/foreign/e_access.html

TUS Science and Technology Museum & TUS Math Museum

During the conference, TUS' Museums are open (Free of charge).

Science and Technology Museum: Thursday, Friday, and Saturday (10:00 – 16:00)
Math Museum: Thursday, Friday (12:00 – 16:00), Saturday, and Sunday (10:00 – 16:00)

ACADEMIC PROGRAM

Invited Guests

PLENARY 1

Exploring K-12 Teachers' Conceptions and Implementation of Integrated STEM

Dr. Gillian H. ROEHRIG (USA)
Professor, STEM Education
Department of Curriculum and Instruction
Faculty of Education
University of Minnesota, Twin-Cities Campus

PLENARY 2

Enhancing "Scientific Literacy" through Chemistry Education in Europe: Wishes and Necessities, Challenges and Opportunities

Dr. Claus BOLTE (Germany)
Professor of Chemistry Education
Department of Chemistry Education
Freie Universität Berlin

KEYNOTE 1

Lesson Study as One Art of Investigation for Practitioners and Researchers

Dr. Tetsuo ISOZAKI (Japan)
Professor of Science Education
Graduate School of Education
Hiroshima University

KEYNOTE 2

Talking and Doing Science in the Early Years - A New Rationale and Implementation in the 21st Century

Dr. Sue Dale TUNNICLIFFE (UK)
Reader in Science Education
Department of Curriculum, Pedagogy and Assessment
Institute of Education
The University College London

KEYNOTE 3

Integrating Education for Sustainable Development (ESD) into Science Education

Dr. Sun Kyung LEE (Korea)
Professor of Science Education
Department of Science Education
Cheongju National University of Education

KEYNOTE 4

International Perspectives on Science Museum for Science Learning: Cultural Assumptions as Barriers to Pedagogical Innovation

Dr. David ANDERSON (Canada)
Professor
Department of Curriculum & Pedagogy
Faculty of Education
University of British Columbia

KEYNOTE 5

e-Learning in Science Classroom: The Good, the Bad, the Ugly and the Future – A Personal Journey

Dr. Chun-Yen CHANG (Taiwan)
NTNU Chair Professor
Director of Science Education Center
Graduate Institute of Science Education & Department of Earth Sciences
National Taiwan Normal University

KEYNOTE 6

Learning Progressions in Science: Building Coherence across Standards, Curricula and Assessment

Dr. Ravit Golan DUNCAN (USA)
Associate Professor
Graduate School of Education
The Rutgers University

KEYNOTE 7

Striving to Make a Change in Science Classrooms: implications from Teacher Education

Dr. May May-Hung CHENG (Hong Kong)
Chair Professor
Department of Curriculum & Instruction
The Education University of Hong Kong

KEYNOTE 8

Science Education Research and the Learning Sciences

Dr. BaoHui ZHANG (China Mainland)
Qujiang Scholar Professor
School of Education
Shaanxi Normal University

Executive Summaries of Invited Speeches

Plenary 1

Exploring K-12 Teachers' Conceptions and Implementation of Integrated STEM

Gillian Roehrig
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Department of Curriculum and Instruction
Faculty of Education
University of Minnesota, Twin-Cities Campus, USA
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[Presider] Yoshisuke Kumano, Shizuoka University (Japan)

August 26, 2016. Friday
09:40-10:20 Room A
(Live Remote: Room Breakroom 1, B, C, D & E)

Numerous national policy documents in the United States have called for improvements in K-12 STEM education. The premise of these reports is that continued progress and prosperity within the United States depends on the development of the future generation of STEM professionals. These calls for improvement of STEM education in the United States are driving changes in policy, particularly in academic standards. In addition, they recommend investment in quality STEM education programs that will increase the quality and knowledge of the teaching force in the STEM fields.

The problems that we face in our ever-changing, increasingly global society are multidisciplinary, and many require the integration of multiple science, technology, engineering, and mathematics (STEM) concepts to solve them. However, while policymakers and educators acknowledge the importance of STEM education, there is no common agreement on the nature of STEM education as an integrated or multidisciplinary endeavor. The Framework for K-12 Science Education (National Research Council [NRC], 2012) and the subsequent Next Generation Science Standards (NGSS; NGSS Lead States, 2013) are the most visible outcome of policy calls for improving K-12 STEM Education. Significant in these documents is the increased visibility of engineering by "raising engineering design to the same level as scientific inquiry in science classroom instruction at all levels, and by emphasizing the core ideas of engineering design and technology applications" (NGSS Lead States, 2013, p. 1).

These national guidelines have a strong influence on state standards within the United States; currently 17 states and the District of Columbia have adopted the NGSS and at least 36 states have some level of engineering integration in their science standards (Moore et al, 2015). Additionally, there are increasing international calls for integrated STEM education (Rennie, Venville, & Wallace, 2012; Organization for Economic Co-operation and Development, 2008). While these policy initiatives represents an important step in realizing improved K-12 STEM education, there exist few general guidelines or models for schools and teachers to follow regarding how to implement STEM integration approaches.

In our work, engineering is viewed as a catalyst for integrated STEM education, as "there is considerable potential value, related to student motivation and achievement, in increasing the presence of… engineering in STEM education in the United States in ways that address the current lack of integration in STEM teaching and learning" (NRC, 2009, p. 150). Rationales for the integration of engineering in K-12 classrooms include (Brophy et al., 2008; Hirsch, Carpinelli, Kimmel, Rockland, & Bloom, 2007; Koszalka, Wu, & Davidson, 2007):

1. Engineering provides a real-world context for learning mathematics and science;
2. Engineering design tasks provide a context for developing problem-solving skills; and
3. Engineering design tasks are complex, and as such, promote the development of communication skills and teamwork.

If these policy documents and the integration of engineering into science classrooms are to lead to improvements in K-12 STEM education, we need to explore new models of STEM teaching and learning, assessment, and professional development. Unfortunately, research on STEM integration in K-12 classrooms has not kept pace with the sweeping policy changes in STEM education. Thus, to promote the development of integrated models of STEM education, the National Science Foundation has begun to fund studies engaged in research on professional development, curriculum development and implementation of integrated STEM.

Minnesota represents a useful case for exploring the impact of policy decisions related to STEM integration. STEM education is valued in the state, the decision to integrate engineering into the state science standards was made in 2009 well in advance of the release of the NGSS. The placement of engineering in the science academic standards as opposed to separate engineering standards and clear statements within the standards frameworks is an unmistakable policy statement that STEM integration is the desired outcome. Critical to the success of STEM education in the state, is the support for professional development for K-12 teachers through regional Mathematics and Science Teacher Partnerships (MSTPs). Our research through the regional MSTPs and subsequent federally funded EngrTEAMS: Engineering to Transform the Education of Analysis, Measurement, and Science in a Team-Based Targeted Mathematics-Science Partnership has led to the development of strong models of professional development (Guzey, Roehrig, Tank, Moore, & Wang, 2014; Roehrig, Wang, Moore & Park, 2011). Our research reveals a continuum of conceptions of integrated STEM (Ring, Dare, Crotty, & Roehrig, 2016) which are related to different implementation approaches from les-

sons and units that attempt to integrate all of the STEM disciplines to engineering only lessons (Roehrig, Wang, Moore & Park, 2011; Roehrig, Ellis, Dare, & Sheldon, 2016).

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Plenary 2

Enhancing "Scientific Literacy" through Chemistry Education in Europe: Wishes and Necessities, Challenges and Opportunities

Claus Bolte

Professor
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Freie Universität Berlin, Germany
http://www.chemie.fu-berlin.de/cgi-bin/personen_en?Claus+Bolte

[Presider] Hiroki Fujii, Okayama University (Japan)

August 26, 2016. Friday
10:20-11:00 Room A
(Live Remote: Room Breakroom 1, B, C, D & E)

Enhancing Scientific Literacy is – in my opinion – the overarching aim of science education. But what do people consider relevant when they discuss the concept or the term "Scientific Literacy", the objectives of science education in general and those of chemistry education in particular? Which image emerges when representatives of different stakeholder groups (e.g. students, teachers, science educators or scientists...) express their understanding of current science and chemistry education practice?

By means of the International Curricular Delphi Study on Science Education I will portray the contours of Science Education practice in Europe, which indicate wishes and desires, necessities and challenges. They represent the variety of opportunities how to improve chemistry education, making science and especially chemistry more attractive and popular with the society in general and young adults in particular.

In my presentation, I will first draw attention to the diversity of aspects which represent the concepts and terms "Scientific Literacy" and "Chemistry Education". I will focus on aspects which are assessed as relevant and desirable in this field by a large sample of European stakeholders (N>2.700). Besides, I will discuss the issues realized to a higher or lower extent in science – especially in chemistry – education in the opinion of the European stakeholders involved in this study. Furthermore, the comparison of the importance and the practical realisation attributed to each aspect allows the identification of areas requiring further improvement and more efforts in order to enhance Scientific Literacy in Europe – and maybe also in Asian countries.

Especially the areas which are assessed as very important but improved satisfyingly in science education practice form the starting point for the development of innovative sequences of science lessons (termed as "modules"), which should support the enhancement of scientific literacy among our students. For the development of these modules, science teachers are of great importance. This is one reason why I will introduce a model for "teachers' continuous professional development

(CPD)", which is based on a cooperation between science teachers and science educators. The CPD model, in which teachers act as partners and in the role of "curriculum developers", has been successfully tried out in 21 different European countries within the framework of an international project funded by the European Commission named "PROFILES". Outcomes of this CPD programme are modules for more successful science teaching and learning as well as a higher level of teachers' professional attitudes, which partners of the PROFILES project term "teacher's ownership".

At the end of my presentation I will introduce one of these modules focussing on the topic "Bioenergy", which was developed in cooperation with science teachers in Berlin. The teachers have implemented the module in their classes and have evaluated it regarding the question how their students become more (intrinsically) motivated to learn science when they are taught based on modules like this. Some years ago we had the opportunity to apply a module like this in the frame of a German-Japanese-Cooperation we named the "German-Japanese Chemistry Class of Its Own". I will use this project as an example to illustrate how to enhance "Scientific Literacy" and demonstrate – on empirically based evidence – the role contemporary Chemistry Education could play in order to achieve this aim of general science education [in German termed "Naturwissenschaftliche Bildung"].

Keynote Speech 1

Lesson Study as One Art of Investigation for Practitioners and Researchers

Tetsuo Isozaki
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[Presider] Jinwoong Song, Seoul National University (Korea)

August 26, 2016. Friday
13:30-14:10 Room A (Live Remote: Breakroom 1 & C)

Science teachers continue their professional development in order to improve their teaching competencies and students' learning. There are several approaches to improving science teaching and learning. Science teachers' ordinary classroom and laboratory practice is the basis for systems to improve teaching and learning within a cultural context, e.g., reflective conversation with colleagues, observation visits and education conferences (OECD 2014), and Lesson Study (LS). Such practical methods are not based on theory but rather on traditional wisdom and expertise of practitioners. On the other hand, as improvement of teaching and learning might follow from research on teaching and learning processes, the integration of research perspectives into teachers' practice is necessary to unite practice and research. Understanding the aspects of knowledge that teachers interpret and transform for science lessons and the reasons for doing so will help bridge the gap between practice and research.

In Japan, LS is an important means for improving teaching and learning (Isozaki 2015). However, as LS has traditionally been embedded in teachers' culture in Japan since the late 19th century, there have been only a few attempts to theorize LS. For this purpose, the theories on teacher knowledge of Shulman (1987) and the didactic transposition theory of Chevallard (1989, 1999) might serve to bridge the gap between practice and research.

LS has three parts: preparation, the research lesson, and the reflective meeting/conference. According to a study of LS among lower secondary school science teachers (N=177) carried out in Hiroshima in 2016, 50.8 percent of the teachers responded that within the whole processes of LS, researching and developing teaching materials best facilitated their professional development. Researching and developing teaching materials, and also making and revising a lesson plan (main part of the LS preparation phase) require teachers to identify the lesson's implicit and explicit scientific and didactic values.

Shulman analyzed the concept of a "knowledge base" into seven types of knowledge, of which Pedagogical Content Knowledge (PCK) is associated with other six types of knowledge base such subject content knowledge, curriculum knowledge, general pedagogical knowledge. Compared to novice science teachers, experienced science teachers have structured, layered PCK, and can conceptualize pedagogical reasoning (e.g., Isozaki, et. al. 2007). PCK can play an important role in the LS preparation phase, especially in researching and developing teaching materials, and making lesson plans (Isozaki 2015), because teachers must transform their subject content knowledge in order for it to become teachable and learnable knowledge. According to Shulman's model of pedagogical reasoning and action (Shulman 1987: 16), this transformation would entail the following processes: (1) preparation, including critical interpretation, (2) representation of the ideas as analogies, metaphors, etc., (3) instructional selections of teaching methods and models, and (4) adaptation to the general characteristics of students, as well as (5) tailoring these adaptations to specific students. This transformation helps develop PCK, and is similar to the LS preparation phase.

Chevallard (1989, 1999) calls the process of adapting knowledge in order for it to become teachable and learnable knowledge, is called the didactic transposition of knowledge, and the meaning of knowledge depends on the institution or group; as Tiberghien and Sensevy (2015) pointed out, didactic transposition is a theoretical tool to analyze the curriculum and implement teaching practices. The didactic process includes three steps: (1) from scholarly knowledge to knowledge to be taught, (2) from knowledge to be taught to taught knowledge, and (3) from taught knowledge to learned, available knowledge (Bosch and Gascón 2006). As scholarly knowledge, generally called scientific knowledge in the research context, cannot be directly transferred into the minds

of children, science educators have to transpose scholarly knowledge into teachable and learnable forms, called knowledge to be taught in the societal context (e.g., formal curriculum, textbooks) by different stakeholders (e.g., educators, curriculum developers, politicians and others), and then taught knowledge in the classroom, while keeping its power and functional character. The transposition from knowledge to be taught to taught knowledge can be observed at the LS preparation phase.

While LS is important for developing a teacher's professional knowledge, researchers can use theories on teacher knowledge and didactic transposition to analyze the transformation/transposition of professional knowledge of novice and experienced teachers in LS for the purpose of feedback to them respectively, e.g., what is transposed/transformed and why, and help teachers draw on their knowledge to decide what and how to teach.

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Key words: Lesson Study, Knowledge, Pedagogical Content Knowledge, Didactic Transposition Theory

Keynote Speech 2

Talking and Doing Science in the Early Years - A New Rationale and Implementation in the 21st Century

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The University College London, UK
https://www.ioe.ac.uk/staff/CPAT/GEMS_23.html

[Presider] Manabu Sumida, Ehime University (Japan)

August 26, 2016. Friday
13:30-14:10 Room B (Live Remote: Room D & E)

We are experiencing a paradigm shift in our understanding of science learning. Increasingly in the literature and at conferences educators are discussing early years science learning and its crucial role in the development of a person's science capital, (Archer r et al., 2015). Why? Pre school children are not 'tabula rasa' but competent scientists even before they can verbalise. But theirs is children's science. There is Children's science, School science and Scientist's science (Osborn, Bell and Gilbert, 1983). The foundations of Science understanding are laid in the earliest years of life. Children, before formal school (particularly 1 to 5 yrs.), are intuitive scientists and adults can be so important in this early critical stage of learning. Piekney et al (2013) have shown that preschool children already have a basic ability to evaluate evidence and a basic understanding of experimentation. Gopnik (2009) shows that young pre school children are intuitive scientists observing, asking questions, investigating, collecting data. Baruch and Specktor-Levey (2014) discus their work on using preschoolers verbal behaviour and responses an indicators of attitudes and scientific curiosity. Indeed Tunnicliffe and Uckert (2011) have suggested that there is a critical time for science learning in these early years as there is one it is thought to be for language acquisition (e.g. Johnson and Newport, 1991). Young children observe and investigate constantly if allowed to do so. Much of the play that they invent contains science experiences as well as everyday experiences which are science in action. Johnson (2005, p 33) claims that observation is the 'most important skill in science and the first we develop'. Indeed, Broadhead (2006) highlights the importance of understanding the tremendous importance of a young child's play in observation, interaction and reflections, vital components of science. Moyles (1989) discusses the importance of so called play in a child's learning. Careful participation of adults in the spontaneous observations and investigations of the very young can be a critical intervention in the positive development of a child's scientific literacy. Vygotsky (1962) stresses the importance of support of an adult in constructive leaning. Such is vital in these early years, not to instruct but to support. This involvement means talking to them, listening to their ideas, cuing them to think further. It does not mean explaining the theory in old-fashioned formal teacher mode! Learning science and associated subjects such as language, numeracy and social

skills of cooperation, communicating are key competences in the learning journey of a child through all aspects of learning but of immense importance in their science repertoire. An issue is that preschool educators' attitudes to science can 'shape children's engagement in science and their curiosity' or not. Spektor –Levy,Baruch, and Mevarech (2013) investigated this. Finding that people involved in early years considered science activities in this early age were important but they themselves felt inadequate. However, research into how children learn is becoming more frequent, such as the work of McGuigan and Rusell (2015) looking at the learning process and effective in a particular biological domain.

Thus, science learning does not start at secondary school, nor does it begin in the primary school, nor even in preschool, it begins from birth. Each successive stage builds on these foundations. It is a partnership between all participants. The most important people in the development of a child's science store are their adults and older children with whom they into contact. Nor must we underestimate the role of all media in this and the conflict between reality and fantasy they perpetuate School teachers, especially science educators in senior school, do not enjoy hearing this and usually do not agree. This talk will illustrate the importance of the earliest science encounters of a child's life in the everyday world, which they inhabit. Their observations and exploitations can be helped or hindered by their adults. Such 'first teachers' do not tell them the science information but encourage the learner to observe, question, seek patterns and ask, " Why?" " I wonder what happens if… I…". Alas, this natural gift often is extinguished once they start school with the rigid curriculum and tests. We are science education researchers, it is our role to help and find out the optimal means of developing this potential. In both learners and their adults.

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Keynote Speech 3

Integrating Education for Sustainable Development (ESD) into Science Education

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August 26, 2016. Friday
14:10-14:50 Room A (Live Remote: Breakroom 1 & C)

Sustainable Development Goals (SDGs) and Education for Sustainable Development (ESD) are two of the most important discourses at present. The United Nations Sustainable Development Summit in September 2015 adopted the 2030 Agenda for Sustainable Development, with 17 SDGs including quality education, to end poverty and transform the world. Muscat Agreement by the Global Education for All Meeting in 2014 and Incheon Declaration of the World Education Forum in 2015 emphasized ESD and global citizenship education (GCE) in post 2015 global education goals and targets. UNESCO, as a leading agency of the UN Decade of ESD (2005-2014), continues to implement Global Action Programme for ESD. In this sustainable development era, it would be a significant task to explore what science can contribute for sustainability and how ESD can be integrated into science education and school practices.

Conventionally, it has been argued that the practice of science is in value-neutral approach and science, technology and society are present independently. Value orientation of science,

however, became important in the present, as the boundaries of science and technology are vague and ambiguous, and science and society are closely linked to affect each other. Similarly, the perspectives of scientific literacy have been expanded, which often expresses what should constitute the science education of all students. According to Roberts (2007) differentiating Vision I and Vision II after extensive literature review of scientific literacy, Vision I 'gives meaning to scientific literacy within science by looking at the products and processes of science itself.' Vision II of scientific literacy is interested in literacy about 'science-related situation,' which 'derives its meaning from the character of situation with a scientific components and situations, which students are likely to encounter as citizens.' If science educators orient Vision II of scientific literacy in their practices of science education, there might be plenty of ways to integrate ESD into science education towards sustainability.

How to integrate ESD into science education can be explored in various levels and with diverse elements. First, ESD can be implemented in science education practices through the introduction of contents related to sustainable development and its principles and provisions (Burmeister & Eilks, 2012; Jestard & Sinnes, 2013; Fujii & Ogawa, 2015). Second, competence-based approach towards ESD can be used, which includes critical thinking, system thinking based on understanding the complexity of wicked issues in the real world (OECD, 2003; Adomßent & Hoffmann, 2013; Sleurs, 2008; Tschapka, 2014). Third, interdisciplinary and transdisciplinary approach may be added using STEAM (science, technology, engineering, art and mathematics) approach or other types of convergence education. Lastly, whole-school approach might be used to mainstream ESD in school practices through whole-school inquiry themes or other overarching doorway themes investigated in the sustainable schools initiatives in the U.K. (Breiting et al., 2005, Hendrson & Tilbury, 2004; DCSF, 2007; Hunt & King, 2015).

This presentation will explore various efforts and cases in integrating ESD into science education and school practices in Korea, Japan, and the U.K. to provide implications for innovative science education practices and research.

Keynote Speech 4

International Perspectives on Science Museums for Science Learning: Cultural Assumptions as Barriers to Pedagogical Innovation

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14:10-14:50 Room B (Live Remote: Room D & E)

There has been a tremendous growth in the number of Science Museums and Science Centers that have opened across the world in the past few decades – particularly in Asia. Broadly speaking, their missions are one of service to society in order to enhance scientific understandings, literacy and interest among a board diversity of citizens, including children, teenagers, families, K-12 students, and seniors. However, there continues to remain gaps between how museums can effectively realize their mission which in part are limited by implicit assumptions in the foundations of their origins and educational philosophies. Based on empirical research studies conducted in various Asian and Western countries, I argue that there are a number of barriers and inhibitors, as well as mismatches in museum pedagogy, which limit the effectiveness of science museums as cultural resources for science learning. This presentation will argue that identifying and realizing such barriers and mismatches holds the promise for reforms that may lead to more educationally effective use of science museums for science education and help improved scientific literacy for the broader society. Four key themes to be discussed include:

1) Recognizing cultural distinctiveness of audiences across national boundaries – Nations have cultural, social and political distinctiveness which influence their values about education and how their citizens engage in educational enterprises. Accordingly, there is a need to appreciate national cultural distinctions in how people engage in free-choice learning, and how museums think about the mediation of experiences for science education.
2) Cultural assumption implicit in the knowledge base – Much of the world-wide published research in learning in informal setting is culturally-homogeneous – dominantly (and historically) conducted in Western cultural contexts and with Western audiences. Yet, much of the understandings about science museum practices and pedagogy, and how visitors learn, are extrapolated and applied across contexts without much questioning of the cultural origins of the findings. As such, philosophical and pedagogical assumption implicate in research finding ought to be scrutinized thoughtfully, to the localized context, before application.
3) Cultural appreciation of audiences across the lifespan – Human beings learn in distinctly different ways as a function of life stage, as the needs and interests of each stage vary. Yet, the pedagogy of the museum in how audiences engage are in many instances homogenous and non-responsive to these variances. Accordingly, revising the pedagogy of the museum to meet audience learning needs and in keeping with their socio-cultural identities require careful thought.
4) Assumed cultural roles and responsibilities of stakeholders in informal education – Within the enterprise of informal education there exist multiple stakeholders (e.g., parents, teachers, museum staff). Mismatches in expectation of roles among stakeholders lead to tensions and ineffective or stifled educational practice and outcomes. Questioning and clarifying roles holds the potential to improve synergy within stakeholder partnering for more effective educa-

tional outcomes, and realization of intended educational missions.

This presentation, through the act of questioning cultural assumptions, will shed hope for fostering richer, more meaningful, utilization of science museums to the broader benefit of more scientifically literate societies.

Keynote Speech 5

e-Learning in Science Classroom: The Good, the Bad, the Ugly and the Future – A Personal Journey

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August 27, 2016. Saturday
13:30-14:10 Room A (Live Remote: Breakroom 1 & C)

In this talk, I would like to share with you, my personal journey in e-Learning research, practice and experiences, including:

1) The GOOD: new technologies bring science educators new hope, which usually promises to better student learning through innovations, such as clickers, and CAL (computer assisted learning), and more recently, ITS (intelligent tutoring system), MOOCs (Massive Open Online Courses), learning analytics, digital game-based learning, to name just a few;
2) The BAD: e-Learning tools, including hardware and software, advance so fast that it is generally hard to keep up with them, therefore, leading to a sad situation in terms of high costs and low amounts of preparation by both the instructors and students;
3) The UGLY: there is nothing new under sun, especially when it comes to new technologies employed in school in terms of concepts/ideas in improving student learning. Addictions and our focus on new technologies make people miss the real opportunities to guide students to learn better; and finally,
4) The FUTURE: some possible suggestions and studies/practices will be provided in light of this personal journey, with the hope of getting e-Learning back to the basics, which can be traced back to David Ausubel's view of learning: determining what students already know first, and teaching them accordingly.

Based on my reflection on e-Learning research, practice and experiences, a next-generation clicker system - CloudClassRoom (CCR) has been developed. Clickers are signal transmitters, similar in size to television remotes, used to collect students' responses to teachers' questions in the classroom. In CCR, the teacher poses a question, generally a multiple-choice type inquiry; students can then click the buttons on their remote-like devices to specify answers to questions. Students' answers are then transmitted to a monitoring system typically through infrared or radio frequency signals. By this means, every student in the classroom can express his/her thoughts instantly without being scrutinized by peers. The monitoring system then automatically aggregates the answers from the entire class with a histogram; the system then offers the teacher a choice about whether or not the overall distribution of students' answers should be publicly shown.

Clickers have been widely advocated as a useful tool to reform classroom learning because: 1) it can nurture a sense of classroom participation and thus makes students feel accountable to the academic task exercised in the cla27SS2) the real-time data collected by clickers can assist teachers in tailoring feedback to address students' difficulties just in time. However, to deploy clickers into every classroom, schools have to invest a lot of money for buying or renting hardware. Furthermore, the distribution and safekeeping of clickers in the classroom are not easy for teachers. To overcome these barriers, I have thus developed CCR with my students. CCR is developed using HTML 5.0, PHP, and MySQL. Such a technical design makes CCR work on every Internet-capable device without further software or plug-in installation. It also allows CCR to operate across-platforms, regardless of system being iOS, Android, or even Windows; and, it is compatible with a range of devices, such as smart phones, tablet computers, personal computers, and laptops. Thus, teachers and students are able to transform their own devices into clickers once they connect their devices with CCR on the Internet. Adopting web-based clickers is a more economical solution for schools, especially for those already equip with Internet access and Internet-capable devices. Such a solution will become more cost-effective as more and more schools start embracing the Bring-Your-Own-Device (BYOD) policy. Web-based clickers are well compatible with the digital devices that many students already own. In addition, web-based clickers are a far better research tool than traditional clickers in terms of obtaining learning analytics in a large-scale manner. With the CCR, a school is able to use one central monitoring system to access all students' data, regardless of which classroom the data is collected from. This system design also facilitates national or even global level research on learning analytics obtained from a group of real classrooms.

The web-based infrastructure of CCR allows researchers to customize clicker functions, based on educational studies, to support better teaching and learning. The insights obtained from my research into classroom learning have been translated into CCR. Two groundbreaking functions will be demonstrated during my talk, including:

1) Real-time analysis on free-text responses: The question formats of traditional clickers are limited to true-false and multiple-choice questions because only numeric responses are accepted. However, such the design might be an obstacle for teachers to make students focus on reasons, rather than answers. The presentation of a true-false or multiple-choice question is basically asking students to vote for answers, not for how they arrive at their answers. Even

if each answer option is attached with a prescribed explanation, it may not adequately represent various students' reasoning processes. CCR thus provides teachers with the open-ended question format. Through the use of PCs, laptops, smart phones, or tablets, students are enabled to use textual responses to submit their explanations for clicker answers. Moreover, Natural Language Processing (NLP) techniques have been incorporated into CCR to automatically analyze students' free-text responses in real time based on the semantic similarity and then generate a diagnosis report. This function substantially helps teachers to understand students' thinking processes and diagnose students' learning difficulties more deeply and precisely.

2) Heterogeneous group formation: It is known that frequent exchanges in reasoning are an important character of productive discussion. Through iteratively attending to, and dissecting contradictory opinions, students are more likely to jump out of the box and then find the blind side of their own reasoning. However, in order to do so, students must have some food for thought; it would be difficult for a group to pull some new ideas out of thin air if each group member comes up with the same ideas. It is thus critical to orchestrate groups for students in which diverse ideas are represented. Arranging students who hold different clicker answers into a group should be an effective way to increase the diversity within groups. CCR is embedded with an automatic function to from small groups based on students' real-time responses. For instance, if the teacher poses a yes-no question and chose to form heterogeneous dyads, CCR will randomly assign students with conflicting answers (i.e., one of them responded: Yes, and the other responded: No) into dyads. Students then follow the instructions provided by CCR to find their group members and initiate peer discussions. Leveraging the aforementioned features of CCR, teachers certainly can save a lot of time collecting students' responses and arranging heterogeneous groups. The classroom activities aiming to enhance the quality of peer discussion may thus be implemented in a much smoother manner.

To date, approximately 2000 teachers have registered in CCR. More than 9000 classrooms have been established on CCR. Over 10000 classroom activities have been conducted by using CCR. Nine different language versions of CCR have been released, including Chinese, English, French, Japanese, Arabic, Turkish, Korean, Swedish, and Vietnamese. Several empirical studies have been preliminary done and demonstrated the usability of CCR. I am currently leading in-depth studies to examine the how students learn with CCR. In order to collect empirical data in a large-scale manner, CCR has been further integrated with the learning management system of my university. We are seeking more international research partners to co-develop and co-examine the educational benefits and challenges of using CCR. It can be expected that CCR will be fine-tuned to create differential advantages for various users all over the world in the near future.

Keynote Speech 6

Learning Progressions in Science: Building Coherence across Standards, Curricula and Assessment

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August 27, 2016. Saturday
13:30-14:10 Room B (Live Remote: Room D & E)

Learning progressions embody a developmental approach to learning by describing hypothetical paths that students might take as they develop progressively more sophisticated ways of reasoning about scientific concepts and practices in a domain over extended periods of time (Corcoran, Mosher & Rogat, 2009; Duncan & Hmelo-Silver, 2009; National Research Council, 2007; Smith, Wiser, Anderson & Krajcik, 2006). While the scholarship on learning progressions in science is still in its early stages, these progressions have captured the attention of funding agencies and policy makers in the United States. The Framework for K-12 Science Education (National Research Council, 2012) and the Next Generation Science Standards (NGSS Lead States, 2013) in the U.S. both emphasize the potential of learning progressions in providing greater coherence and better alignment of standards, curriculum, and assessment.

In many ways learning progressions are not a new idea and share similarities with other constructs that focus on the development and deepening of children's knowledge over time such as Bruner's (1960) spiral curriculum, Vygotsky's zone of proximal development (Vygotsky, 1978), and developmental corridors (Brown & Campione, 1994). However, the specific construct of learning progressions in science was first mentioned in the Systems for State Science Assessments report (National Research Council, 2006); thus learning progressions in science have strong roots in the world of assessment and measurement.

Science learning progressions also share some similarities with mathematics learning trajectories, which have a longer history (Carpenter & Lehrer, 1999; Clements & Sarama, 2009; Fennema, Carpenter, Frank, Levi, Jacobs & Empson, 1996). While somewhat similar, the mathematics learning trajectories differ from science progressions in two key ways. First, mathematics trajectories tend to be grounded in teaching experiments and were developed through close and iterative work in mathematics classrooms. Second, they include much more specification about the tasks that can be used to move students' thinking forward along the path; thus mathematics trajectories include pedagogical approaches and strategies as an integral part of the trajectory itself (Clements & Sarama, 2009; Daro, Mosher, & Corcoran, 2011).

There are four key features that characterize learning progressions in science (Corcoran et al., 2009). First, progressions are centered on a few foundational and generative disciplinary ideas and inquiry practices. Several researchers have argued that it is the combined focus on content and practice that is unique to the current definition of science progressions (Smith et al., 2006, Songer, Kelcey & Gotwals, 2009; Schwarz et al., 2009). Second, progressions are bounded by a lower anchor describing assumptions about the prior knowledge and skills of learners as they enter the progression, and by an upper anchor describing the expected outcomes by the end of the progression. The upper anchor is predominantly determined by societal expectations and analyses of the domain. Third, learning progressions describe the development of students' understandings as intermediate stepping-stones or levels between the two anchors. These levels are derived from analyses of research on student learning in the domain. Progressions also include descriptions of expected learning performances at each level that can be used to track student progress. Fourth, learning progressions are mediated by targeted instruction and curriculum. That is, they describe learning as facilitated by carefully designed learning environments.

It is important to note that learning progressions by their very nature are hypothetical; they are conjectural models of learning over time that need to be empirically validated (Duncan & Gotwals, 2015). In developing a validity argument for a learning progression one is trying to determine if the nature and order of the proposed intermediate steps fit empirical data on student thinking from cross-sectional studies (Mohan, Chen & Anderson, 2009; Stevens, Delgado & Krajcik, 2010), and teaching experiments (Gunckel, Mohan, Covitt, & Anderson, 2012; Songer et al., 2009). Constructing a validity argument for a progression entails the development of assessment items for the different levels of the progressions. Thus assessment and measurement is an integral aspect of learning progressions scholarship (Briggs, 2012).

My own research in this area has focused on the development and refinement of a learning progression for genetics spanning late elementary to high school (11- 16 year olds) that was developed in collaboration with Aaron Rogat and Anat Yarden (Duncan, Rogat, & Yarden, 2009). The progression is grounded in a framework for genetics literacy proposed by Stewart, Cartier and Passmore (2005) which argues that genetics literacy entails understanding three interrelated conceptual models and the relationships between them: (a) the inheritance model, which explains the probabilistic patterns of correlation between genes and traits; (b) the meiotic model, which explains the cellular processes that allow for the transfer of genetic information from one generation to the next; and (c) the molecular model, which explains the cellular and molecular mechanisms by which genes bring about their physical effects within an individual. In developing the progression we therefore identified eight constructs that map onto these three conceptual models, interactions between them, as well as interactions with the environment (Duncan et al., 2009). Progress along the progression entails developing more sophisticated mechanistic explanations of genetic phenomena that draw on ideas embodied in the eight constructs.

Over the past decade my research team (Duncan, Castro-Faix, & Choi, 2014; Freidenreich, Duncan, & Shea, 2011; Shea & Duncan, 2012) and others (Todd & Kenyon, 2015) have engaged in the study and revision the progression (Shea & Duncan, 2012; Todd & Kenyon, 2015; Castro-Faix, Rothman, Seryapov, & Duncan, 2016). Towards this end we have developed numerous assessment items for the various constructs as well as instructional materials aimed at facilitating learning along the progression. This work has led to novel insights about genetics learning, the development of students' understandings, and refinement of several constructs of the progression. In my presentation I will provide an overview of learning progressions and discuss the research efforts around these progressions using examples from my own work on the genetics progression as well as the work of others in the field.

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Keynote Speech 7

Striving to Make a Change in Science Classrooms: Implications from Teacher Education

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August 27, 2016. Saturday
14:10-14:50 Room A (Live Remote: Breakroom 1 & C)

It is a concern among science educators that innovative pedagogical methods are not translated into classroom practice. To draw an analogy, science educators, curriculum developers and drivers for education reforms may not want to observe a cyclone or hurricane on the surface when life on the floor of the ocean has no turbulence at all. A number of ways to analyze the issue are to be suggested. A brief examination of the meaning and generation of the knowledge of teaching shows that teaching needs to be problematized, and with new designs, new knowledge can be generated. Consistent with the notion that theory is built with the support of concrete examples or experiences, researchers have advocated the creation of practitioner knowledge which is linked with practice and which addresses problems of practice. Teachers are involved in elaborating the problems, analyzing classroom practice, considering alternatives, and testing and recording new knowledge which is then to be shared. Conversely, if research is seen to be disrespectful of teachers' knowledge of teaching, it is unlikely that the innovations suggested by researchers will be adopted.

Research has shown that there are other reasons to explain the difficulty of transferring research-based knowledge into teaching, including the fact that teachers are not convinced of new teaching innovations, and the lack of good communication between researchers and teachers. Moreover, teacher beliefs serve as a filter for research-based knowledge. Teachers with beliefs that curricula or teaching can be changed and improved will be more ready to adapt to innova-

tive practices. In order to be ready to adapt, teachers need to be interested in different perspectives and in pursuing alternative possibilities.

The process of improving practice and generating new knowledge requires collaborations between researchers and teachers. Possible directions for making a change will be suggested including the introduction of practitioner research, developing better communication between researchers and teachers, as well as facilitating teacher agency and ownership. The relationship between practitioner and researcher knowledge can be built in a way that teachers use their knowledge to test and implement new ideas. With this implementation, new hypotheses can be built based on teachers' experience and observations. Researchers can then draw on classroom implementation experiences and generate new generalized knowledge. In a similar vein, teacher learning can be described as a process of construction and reconstruction of knowledge which involves individual and collaborative inquiry. Interactions between researchers and teachers are crucial to the success of implementing new practices in the classroom. Both parties can be engaged in reflective thinking, which is considered to be useful in enhancing teaching performance. The other key to success is to facilitate teacher ownership of or agency for the teaching innovations. Teachers with a strong sense of agency will be knowledgeable of themselves, possessing a drive and the skill to improve their teaching, and will also be responsive to students' needs. If teachers develop a connection between the innovation and their students' needs, and see how the innovation suits them personally, the personalization will make it their own and will increase individual investment in the innovation.

Keynote Speech 8

Science Education Research and the Learning Sciences

BaoHui Zhang
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[Presider] Winnie Wing Mui So, The Educaton University of Hong Kong (Hong Kong)

August 27, 2016. Saturday
14:10-14:50 Room B (Live Remote: Room D & E)

The EASE (East-Asian Association for Science Education) 2016 conference theme is "Innovations in Science Education Research & Practice: Strengthening International Collaboration". To be aligned with the conference theme, there is a need to learn how research paradigm change, which can be part of any innovations in research, affects science education research and practices. A new research paradigm, the learning sciences, is explored in connection to innovations in science education research & practice in the context of globalization. The following research questions guided this study: 1) What can be innovations in science education research & practice？ 2) What are the relationships between science education and learning sciences research communities and research? and 3) How to advance science education and learning sciences research and practice through international collaboration?

Various types of search were conducted on general search engines and some English and Chinese literature databases. Information of the intersection of science education and the learning sciences was retrieved and selected. Content analysis was conducted in regard to the above questions on the following items: 1) Organizations (e.g. the International Society of the Learning Sciences and the National Association of Research on Science Teaching), 2) Journals (e.g. Journal of the Learning Sciences and Journal of Research on Science Education), 3) Representative books (e.g. the International Handbook of Science Education and the Cambridge Handbook of the Learning Sciences) , 4) Scholars, and 5) Representative projects (e.g. research topics, methods, results of research, the effectiveness and long-term impact of the projects).

Results revealed that the importance of science education has been recognized internationally including the learning sciences communities; science education had been a popular context of learning sciences research. On the other hand, learning sciences research produced knowledge and methods on how people learn different subjects including science; learning sciences has also provided principles about how to design and implement effective learning environments such as those for science education. There are scholars, journals, books, and organizations that are involved in scholarship in both science education and the learning sciences. For example, Professor Roy Pea and Allan Collins here are internationally well-known learning sciences scholars who have profound interests in science education. Pea and Collins (2008) describe four waves of science education reforms in the US. The first wave happened in the US from the 1950s to the 1960s; the reform was followed by similar reforms in other countries. The reform was characterized by the development of new science curricula that introduced scientific advances and emphasized scientific methods. The other three waves of science education reforms are cognitive science reform wave (1970s–1980s), the standards reform wave (1980s–1990s), and the systematic approach reform wave (2000s to date).

The dual domains of science education and the learning sciences have co-evolved and been mutually shaping. The presentation proposes more idea sharing and proposals for strategies to strengthen the collaboration among organizations and people who are in science education and the learning sciences across the world.

Key Words: Science Education Research, the Learning Sciences, International collaboration

Symposia, Workshops, & Demonstrations

SYMPOSIA

Symposia 1 (26th, 16:30-18:30)

[26SS1A] Museum Literacy Cultivated through the Communication with Museum Staffs and the Public (*A0229*)

Yoshikazu Ogawa[+*1], Reiji Takayasu*[2], Kôzi Hayasi*[3], Tsutomu Owada*[4], David Anderson*[5], Motoko Shonaka-Harada[1], and Mika Matsuo[1]

1. National Museum of Nature and Science, Tokyo, 2. Chiba City Museum of Science, 3. Natural History Museum and Institute, Chiba, 4. Obihiro Centennial City Museum, Japan and 5. The University of British Columbia, Canada

ABSTRACT National Museum of Nature and Science, Tokyo (NMNS) and other partner museums run an interactive online database system called "Science Literacy Passport β" , also known as PCALi (Passport of Communication and Action for Literacy), as a tool for a government funded research project . It is operated thanks to synergistic partnerships with like-minded museums that are not necessarily science themed. The museums involved are science museums, science centers, zoos, aquariums, history museums, integrated museums and art museums. Detail description of each educational program is input into the database by those museums' staffs using a common framework which was proposed in the conference of PCST 2010 (Ogawa et al., 2010). The research project has two purposes. The first is to establish a museum utilization model in which science literacy is fostered in knowledge circulating society. The second is to establish an interactive lifelong learning system as a new function of museums. Within the first purpose, the word "science literacy" is used. However, it was recently replaced with "museum literacy" as the project involves not only science museums but also all other sorts of museums. The researchers in the team are trying to figure out the importance of three different types of museum literacies. They are the museum literacies of managers, museum staffs and the public. In this symposium, the museum literacy of museum staffs and the public will be the focus. First, Yoshikazu Ogawa will explain the overview of the project. Then, Koji Hayashi will introduce an educational program which encourages the citizen's critical thinking on social issues followed by Tsutomu Owada's talk about an interdisciplinary educational program conducted in collaboration with a history museum and a zoo. They will include their perspectives on the museum literacy of museum staffs and the public. Next, David Anderson will give comments on this research as an independent external evaluator. Finally, there will be a discussion where all the presenters and audience can exchange thoughts and ideas on museum literacy of museum staffs and that of the public. This session will be facilitated by Reiji Takayasu. This work was supported by JSPS KAKENHI Grant Number 24220013.

[26SS1B] The Strength and Weakness of Science Teacher Preparation Program System in Asia Area (*A0518*)

Young-Shin Park[1]*, Xiao Huang[2], Wing Mui Winnie So[3], Yoshisuke Kumano[4], Tomoki Saito[4], Sungho Kim[5], Phil-Seok Oh[6], Corrienna Abdul Talib[7], Muhammad Abd Hadi Bunyamin[8], Christine Tippett[9], Todd Milford[9], and Supara Bakavou[10]

1. Chosun University*, Korea, 2. ZhiJiang Normal University, China Mainland, 3. The Education University of Hong Kong, Hong Kong, 4. Shizuoka University, Japan, 5. Incheon Buyeseo Elementary School, Korea, 6. Gyeongin National University of Education, Korea, 7. Universiti Teknologi Malaysia, Malaysia, 8. University of Minnesota, USA, 9. University of Victoria, Canada, and 10. IPST(The Institute for the Promotion of Teaching Science and Technology), Thailand

ABSTRACT The main goal of this symposium is to address the fundamental system of science teacher preparation programs of Asia area and compare them to learn the strongest of each teacher preparation program system. The goal of science education in each country is to foster scientific literacy in public and it is very critical for the qualified teachers to teach science at schools. Many reports indicate that the quality of teachers lead to different levels of students' achievement in the classroom. What make teachers' quality good in their teaching? How do they teach science as inquiry? How do they teach science as the way of STEM/STEAM? Becoming a science teacher who values and engages in reform-based practices involves much more than acquiring a new set of knowledge and skills and this process must be starting from the teacher preparation program at universities or educational institutes where preservice teachers are trained. After getting trained to be a science teacher, how can he/she be appointed as the teacher? In this symposium, each presenter will introduce the system of science teacher preparation program at universities or training institutes with its strengths, weakness, challenges and risks. In addition, there will be also introduction of innovation in science teacher preparation program in Asia area, which (shall) have been implemented to be resulted in successful one. Lastly there will be comparison among teacher appointing systems so that we can learn what kind of preparing and recruiting systems are best for teachers' expertise. There will be national cases from Korea, Japan, Hong Kong, China mainland, Canada, Thailand, Bangladesh, and Malaysia.

[26SS1D] Teaching Improvement to Promote Students' Disciplinary Competences in Chemistry (*A0479*)

Lei Wang*[+1], Yao Zhi[2], Yanning Huang[3], Fan Shi[1], Dongdong Zhou[1], Yin Chen[2], Lan Wang[4], and Xiaoli Guo[2]

1. Beijing Normal University, 2. Beijing Haidian Teachers Training College, 3. Capital Normal University, and 4. The Experimental High School Attached to Beijing Normal University, Beijing, China Mainland

ABSTRACT The development of student's disciplinary competence is the common demand of science education. Based on the research of disciplinary competence's nature and performance which brought up from the team in Beijing Normal University guided by professor Lei Wang, the symposium focuses on how to promote students' disciplinary competence in chemistry by teaching improvement. There are two parts of the symposium. One is the research framework and method of teaching improvement. The others are three case studies on the teaching improvement to promote students' disciplinary competences in chemistry in secondary school, which are:

research on "teaching improvement based on the chemical practice ability structure "(Yanning Huang); research on "teaching design improvement based on students' disciplinary competence diagnoses——take the organic compounds as an example" (Dongdong Zhou).

[26SS1E] The 2016 EASE Book: Science Education Research and Practice in East Asia: Trends and Perspectives—Findings from the EASE Book Project (2013-2016) (*A0344*)

Chi-Jui Lien[1], Huann-Shyang Lin[2], Tetsuo Isozaki[3], Winnie Wing-Mui So[4], Lei Wang[5], Chun-Yen Chang[6], Myeong-Kyeong Shin[7], Jinwoong Song[8], and Hui-Ju Huang[9]

1. National Taipei University of Education, Taiwan, 2. National Sun Yat-Sen University, Taiwan, 3. Hiroshima University, Japan, 4. The Education University of Hong Kong, Hong Kong, 5. Beijing Normal University, China Mainland, 6. National Taiwan Normal University, Taiwan, 7. Gyeongin National University of Education, Korea, 8. Seoul National University, Korea, and 9. California State University, Sacrament, USA

ABSTRACT Students in East Asia showed relatively well performances in many international comparative studies such as TIMSS and PISA when comparing with that of other parts of the world. Science education in East Asia is drawing attention. This Symposium is to share and discuss some selected findings, the product (book) and experiences from an EASE Book Project which initiated from 2013, then lasted for more than three years. This book co-authored by more than fifty science educators in East Asia makes this project an unprecedented collaborative book writing project. This collaborative EASE Book Project was approved by the EASE Executive Committee in 2014 and has been greatly supported by subsequent EASE Presidents and Executive Committees. With the collaboration, cooperation, and commitment of regional coordinators, chapter authors, and editors (as shown on the EASE E-newsletter of March, 2016 Issue), the dream of having a brain child that is highly associated with EASE and fully developed by members of the association has finally come true. This new book is published by Higher Education Publishing (HEDU) in May 2016. This EASE Book has 15 chapters, which covers history, philosophy, policies, curriculum, students' performances, systems for preparing science teachers, trends of science education research, development of school science, affective aspects of science education, learning in informal environment, modern science and high technology in schools. In this symposium, due to the limited time, six selective themes are presented. The 5 selected presentations for this symposium are (presenter and co-authors for each presentation are listed as above, respectively): 1. Why We Study the History of Science Education in East Asia: A Comparison of the Emergence of Science Education in China and Japan 2. Trend and Development of School Science Education in Taiwan, Hong Kong, and Korea 3. Pre-service Education of High School Science Teachers in East Asia 4. Science Education Research Trends in East Asian Areas: A Quantitative Analysis in Selected Journals 5. Introducing Modern Science and High Technology in Schools We welcome science teachers, educators, researchers in East Asia as well as other parts of the world to join the discussion, to build connections, and to promote science education together.

[26SS1K] Enhancement and Development of Science Education Utilizing Natural Science Museums and Zoo (*A0160*)

Kiyoyuki Ohshika*[+1], Heiwa Muko*[2], Noriko Kawashima*[3], Hiroyuki Furuichi*[4], Rie Akami*[5], and Hideto Okuyama*[6]

1. Aichi University of Education, 2. Faculty of Education, Ehime University, 3. Bunkyo City Bunrin Junior High School, 4. Inuyama City Jyoto Elementary School, 5. Japan Monkey Centre, and 6. Asahikawa City Office, Japan

ABSTRACT In the Course of Study of Japan, it is emphasized more improvement of observation and experiment, natural and scientific experience for students in Science. It is also emphasized more enhancement of the environmental education for constructing of the sustainable and developmental society. Social educational facilities such as natural science museum, aquarium, botanical garden and Zoo are good local effective facilities for science education. In the course of study, it is also recommended utilization of their facilities in science class of elementary and junior high schools. However the cooperation or collaboration between their facilities and schools do not advance well for physical environment such as distance from school to facility. In this situation, there are several good cases succeeding the cooperation and collaboration among them. Many of them were reported that it was good efforts for students to understand not only science but environmental education by cooperation with school and facilities. In this symposium, we are going to introduce some practical cases for cooperation between elementary and junior high schools and their facilities, and discuss current and future issues about the cooperation with them.

Symposia 2 (27th, 16:30-18:30)

[27SS2A] The Development of Science Teachers' Training Programs Focused on ESD: Experiences in Asian Countries (*A0615*)

Hiroki Fujii*[1+], Derek Cheung[2], Agus Fany Chandra Wijaya[3], Shigeyoshi Watanabe[4], Sun-Kyung Lee[5], Sompong Siboualipha[6], Uuriintuya Dembereldorj[7], and Dulguun Jargalsaikan[8]

1. Graduate School of Education, Okayama University, Japan, 2. Faculty of Education, The Chinese University of Hong Kong, Hong Kong, 3. Indonesia University of Education, Indonesia, 4. Faculty of Education, Kumamoto University, Japan, 5. Cheongju National University of Education, Korea, 6. Bankeun Teacher Training College, Laos, 7. Institute of Teachers' Professional Development, Mongolia, and 8. School of Arts and Sciences, National University of Mongolia, Mongolia

ABSTRACT Education for Sustainable Development (ESD), in which UNESCO has taken the initiative since 2004, is now undertaken in the Global Action Program (GAP) on ESD, with the purpose of its worldwide spread. The overarching goal of the GAP is "to generate and scale up action in all levels and areas of education and learning to accelerate progress towards sustainable development" (UNESCO, 2013). One of priority action areas of the GAP is to increase the capacities of educators and trainers to deliver more effectively ESD so that teacher education institutions are expected to distribute pre-service and in-service training on ESD. Subsequently, the International Network of Teacher Education Institutions Associated with the UNESCO Chair on Reorienting Teacher Education to Address Sustainability seeks to be spread ESD internationally, based on various national and regional results of ESD (e.g., Mckeown, 2012).

Moreover, the international cooperation in education pursues ESD implementation into developing counties especially to promote teacher training on ESD. These requests have highlighted a future direction of science teacher education, which fills the important role of advancing teacher education on ESD. The purpose of this symposium aims to discuss the development of science teachers' training programs that are focused on ESD, which our joint-research members have conducted in order to create Asian guidelines and recommendations for reorienting science teacher education to address sustainability. The symposium is hoped to encourage international cooperation in these fields and stimulate workers in Asian countries. The case studies in Indonesia, Japan, Korea, Laos, and Mongolia will be presented to provide a platform for discussions. Firstly, Hiroki Fujii from Japan and Sompong Siboualipha from Laos will respectively report the development of prospective secondary school science teachers' training program on ESD with a special emphasis on science class planning. The framework for these program developments is informed by Stufflebeam's (2003) Context, Input, Process and Product (CIPP) evaluation model. Secondly, Sun-Kyung Lee from Korea and Shigeyoshi Watanabe from Japan will also present the developed pre-service training programs for science teachers, especially biology teachers. Thirdly, Agus Fany Chandra Wijaya from Indonesia and Uuriintuya Dembereldorj and Dulguun Jargalsaikan from Mongolia conducted interviews in both countries with students on physics teacher programs. They will reveal the students' perceptions on sustainable development and ESD. After Derek Cheung from Hong Kong, as a discussant, has devoted a discussion to these innovative science teachers' training programs that integrated ESD, we will finally draw a perspective on further development of the programs in order to bring ESD into the mainstream of science teacher education.

[27SS2B] Public Engagement in Science and Technology in Society: Structures and Changes in the Long Run (*A0278*)

Chun-Yen Tsai[1], Paichi Pat Shein[1]*, Jui-Chou Cheng[2]*, Yuh-Yuh Li[1]*, Ying-Yao Cheng[1], Tai-Chu Huang[1], Jia-Hao Young[1], and Yin-Tze Chen[1]

1. National Sun Yat-sen University, and 2. National Science and Technology Museum, Taiwan

ABSTRACT This panel will address different perspectives in and evaluating public engagement in S&T in society. Nationally representative surveys of public engagement in S&T have been conducted in 2008, 2012 and 2015 in Taiwan. Longitudinal evidence is now available which deserves the attention of science educator and scholars and practitioners. This panel will address four questions arising from such survey of public engagement in S&T: (1)Public engagement would seem to be a necessary but insufficient part of opening up science and its governance. This study focused on investigating the relationship between public self-efficacy and engagement in science. Engagement in science refers to the extent of participation in scientific learning activities. For the populace, it consists of participation in scientific activities during leisure time, including reading or watching science-related television programs, books, websites, radio broadcasts, magazines, or newspapers. Self-efficacy refers to self-confidence in one's ability to complete a task. This judgment of self-confidence influences an individual's choice of actions, level of effort, and amount of time allocated. The authors in the presentation are Chun-Yen Tsai, Yuh-Yuh Li, Ying-Yao Cheng, Tai-Chu Huang (2) This article focuses on Taiwanese citizens' visits to informal science educational institutions (ISEIs) based on the results of the 2008, 2012, and 2015 Survey of Public Scientific Literacy. In the 2015 survey, the largest percentage of respondents reported having visited a zoo, botanical garden, or aquarium (55.2%), followed in descending order by the percentages who had visited the public libraries (52.3%), the natural history museums (34.5%), the science or technology museum (29.2%), and planetariums (16.3%). There was an in increase in the percentages of respondents visiting ISEIs from 2008 to 2015 surveys: the zoo, botanical garden, or aquarium (49.7%, 52.1%, 55.2%), the public libraries (45.7%, 48.5%, 52.3%), the natural history museums (24.5%, 28.2%, 34.5%), the science or technology museum (14.4%, 23.4%, 29.2%), and planetariums (9.7%. 13.3%, 16.3%), respectively for 2008, 2012, and 2015 surveys. There are some differences between urban, suburban and rural areas in terms of the rates at which. The authors in the presentation are Paichi Pat Shein, Jia-Hao Young, Yin-Tze Chen, Ying-Yao Cheng, Tai-Chu Huang (3) "Internet" is recently popular source of information regarding S&T issues. This study investigated Taiwanese citizens utilized the internet for retrieving S&T information and civic scientific literacy in 2015. Three main questions were studied as follows: 1) The characters of citizens' internet access, 2) The internet access for science websites and civic scientific literacy, 3) The frequency of internet access for science websites and civic scientific literacy. The representative adult samples of 1831 Taiwanese citizens were surveyed in 2015. The results suggested that Taiwanese citizens' more frequent internet access for science websites, the greater correlated with civic scientific literacy, it was deserved to investigate how to promote civic scientific literacy by internet access for science websites. The authors in the presentation are Jui-Chou Cheng, Ying-Yao Cheng, Tai-Chu Huang. (4) One dimension of public engagement with science and technology is to encourage public to take part in the decision making process of scientific policy. In this study, we would like to examine the determinants that encourage or deter public from engaging in public policy decision making, controversial social-scientific issue in particular. We measure public willingness to take part in the decision making of science by asking whether they are mobilized to take action to reveal their opinions of some controversial scientific issues. We expect that the empowerment, the understanding of science as lay people and of society as a whole for decisions are critical in examining the science dimension of controversial socio-scientific issues. We employed the data of 2015 Taiwan scientific literacy survey. Regression model is used for statistical analysis. The authors in the presentation are Yuh-Yuh Li, Chun-Yen Tsai, Ying-Yao Cheng, Tai-Chu Huang

The panel, with four speakers from different disciplines of education, sociology and museum researchers, will address these questions also within a view of and cross-disciplinary perspective:

- Dr. Chun-Yen Tsai (Center for General Education, National Sun Yat-sen University) The relationship between public

self-efficacy and engagement in science
- Dr. Paichi Pat Shein (Center for Teacher's education, National Sun Yat-sen University) Survey of visits to informal science educational institutions in Taiwan : 2008, 2012, and 2015
- Dr. Jui-Chou Cheng (National Science and Technology Museum, Taiwan) The relationship between Taiwanese citizens' Internet access for science Websites and scientific literacy
- Dr. Yuh-Yuh Li (Center for General Education, National Sun Yat-sen University) Factors that prevent public from engaging in scientific policy decision making

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[27SS2E] International Cooperation Projects on Science and Mathematics Education for Developing Country from Eastern Asia: Issue and Trends in Japan and Korea (*A0446*)

Kinya Shimizu[1*+], Takuya Baba[1*], Takashi Soma[2*], Youngmin Kim[3*], Jinwoong Song[4*], and Jiyeon Na[5*]

1. Hiroshima University, Japan, 2. Padeco, Co. Ltd., Japan, 3. Pusan National University, Korea, 4. Seoul National University, Korea, and 5. Chuncheon National University of Education, Korea

ABSTRACT It passed more than 20 years since Japan started a comprehensive international cooperation project on science and mathematics education in Philippines. It has extended to various developing countries in Asia and Africa, such as Indonesia, Kenya, Ghana, Zambia, Bangladesh, Ethiopia, Mongol, etc. Now, such cooperation project now yields to implanting Lesson study, commercialization of private company, such as Kumon, Kyoiku-shuppan, Benesse. Now, Korea starts to join the same role in terms of such international cooperation. With similar cultural background, it is important to share the practice and knowledge on cooperation projects on science and mathematics education, in order to identify the strength of each country. Therefore, the symposium on comparative study on international projects was planned. From Japanese side, Prof. Kinya Shimizu will explain the Japanese science education project, and Prof. Baba will present the brief history of mathematics education projects and dissemination of lesson study in Developing countries. Mr. Soma, head of the Bangladesh project, will introduce JICA Bangladesh project from the practical point of view. Profs. Kim and Song will introduce the history and current trends in Science and Mathematics Education projects. In summary, we will identify some commonalities and uniqueness in the cooperation projects in Japan and Korea. 1. Development of Science Process Skills in Cambodia and Analysis of Curriculum Change in Bangladesh (Kinya Shimizu, Hiroshima University) Since the beginning of this century the IDEC at the Hiroshima University jointly has been involved in the Science and Mathematics Education Development in Asia and Africa. I would like to introduce the outline of our involvement and its impact to the country, focusing on Cambodia and Bangladesh. 2. The history of mathematics education projects and dissemination of lesson study in Developing countries (Takuya Baba, Hiroshima University) SMASSE project Kenya, which is one the earliest projects in mathematics and science education cooperation, has started in 1998. This endeavor developed some keywords and framework of activities such as ASEI (Activity based, Student centered, Experiment and Improvisation) and PDSI (Plan, Do, See, Improve). They become standard for the later projects which have developed in SMASE-WESA. However, simple introduction of this framework does not guarantee quality improvement of education. It is in Zambia which employs lesson study approach to overcome this issue. 3. Japan's science and mathematics technical cooperation project in Bangladesh. Takashi Soma (PADECO Co., Ltd.) Bangladesh Government has been committed to the Education for All (EFA) since 1990 and has prioritized primary education as one of the targeted areas of the Millennium Development Goals (MDGs). As a result, the net enrollment rate increased to 97.4 % and the completion rate to 79.6% in 2015 respectively. However, the quality of education has been recognized as major issues. Bangladesh and Development Partners jointly began implementing the Primary Education Development Program II (PEDP II) in 2004 and PEDP3 in 2011, under which Bangladesh Government requested Japanese Government for technical cooperation in improving the quality of primary mathematics and science. By targeting the same goals of PEDP II and PEDP3, JICA Project has been implemented with some unique approaches. 4. Difficulties in collaboration for improvement of primary school ICT education of Kenya (Youngmin Kim, Pusan National University) A collaboration plan for improvement of primary school ICT education of Kenya has been planned by KOICA in Korea. The goal of the plan is to construct two ICT education centers in two primary schools in Nairobi of Kenya, one in one, and to give training of ICT skills and ICT integration teaching method for the primary school teachers. For the successful achievement of the goal, base-line situation in ICT education of the two primary schools were examined. The results are as follows: Firstly, there is no computer in classrooms as well as in teacher's offices of the two primary schools. Secondly, 54% of the teachers have computers in their home, and almost all teachers can use word program, but in case of excelprogram 25% of them have no experience of using it. Nevertheless, their desire to learn computer using skills and ICT integration teaching method is very high. Thirdly, only about 30% of the primary students have computers in their home, but more than 70% of them have experience of using computer program. In addition, their desire to learn computer using skills and ICT integration learning is very high. Recently the government of Kenya has developed a Training Manual for ICT Integration in Primary Education: Training of Education Leaders such as Leading Effective Teaching and Innovative Learning through ICT, ICT Vision, Policy and Implementation Plan; Basic skills, Internet use, Maintenance, Safety, Security and Ethics such as ICT Devices and Use, Introduction to Operating Systems, Application Programs; ICT Integration in Teaching and Learning such as Instructional Practice, Content Knowledge and Curriculum Support, Continuous Lifelong Learning. In the collaboration plan and action, however, there is a big difficulty which they should overcome the gap between present situation and future expectation of MOE of Kenya. 5. International Collaborations through ECCO-SM (East-Asian Classroom Culture of Science and Mathematics) Project in Korea (Jinwoong Song, Seoul National University and Jiyeon Na, Chuncheon National University of Education) The ECCO-SM project is a three-year project supported by National Research Foundation (NRF) in Korea as a part of SSK (Social Science Korea) project scheme. The SSK scheme supports various research projects in the field of social sciences, including education. Every new project in SSK scheme starts from Small-scale Phase which supports projects for three years. Some suc-

cessful projects from this Phase are to be assessed and selected to proceed to Medium-scale Phase which supports for another three years. Then, among successful Medium-scale Phase projects, a small number of projects are to be selected for Large-scale Phase which would support for another four years. The ECCO-SM is now in its last year of Small-scale Phase. The ECCO-SM group is consisted of five co-researchers (Jinwoong Song at Seoul Nat'l Univ. as PI) and several post-graduate students majoring science and mathematics education. With its official title of 'Identifying the characteristics and mechanism of science and mathematics classroom culture in East Asia through socio-cultural lens', ECCO-SM focuses on identifying the features of and investigating the factors of classroom culture concerning so-called 'East Asian Phenomena': East Asian tradition and culture, high achievement but low engagement, classroom silence and norms, (social) face and classroom interaction, classroom as a community of practice, image of learning, and so on. International collaborations of ECCO-SM project are at present mainly through sharing the tools for investigating science classroom culture and interactions in different sets of participating countries. Firstly, SCaCop (Science Classroom as Community of Practice) (Chun, Na, Joung, & Song, 2015) is a newly developed instrument to see how closely a science classroom can be considered as a community of practice. SCaCop is consisted of five factors (i.e. responsibility of leaning, common interest, mutual relationship, open participation, and practice) and of a total of 27 items of Likert style. Science educators from four countries (i.e. Japan, Korea, Taiwan, and Thailand) are participating in a comparative study based on the responses of around 800 elementary and secondary students from each country. Secondly, two well-known tools for classroom environment, WIHIC (What is Happening In This Classroom) (Fraser, Fisher, & McRobbie, 1996) and CLEQ (Cultural Learning Environment Questionnaire) (Fisher & Waldrip, 1997), are applied to about 1600 students (of grade 4, 6, 8, and 10) in two countries (i.e. Korea and Thailand) to compare the features of science classroom environments of elementary and middle schools in the countries. Lastly, EP-IC-S (Engagement and Participation in Classroom – Science), a new instrument being developed, is going to be used to check students' participation in science classroom with about 450 secondary students (grade 7, 9, and 11) from Korea as well as Taiwan. In this presentation, we will give an outline of these international collaborations being taken along with the project of ECCO-SM and discuss some of preliminary findings and plans for future development.

[27SS2G] Studies for Facilitating Students' Learning of Science—Symposium of Association of Science Education in Taiwan (ASET) (*A0345*)

Sheau-Wen Lin[1]*, Mei-Hsiu Chen[1], Jing-Ru Wang[2], Silvia Wen-Yu Lee[3], Sung-Tao Lee[4], Meng-Tzu Cheng[5], Yu-Ling Lu[6]*, and Chi-Jui Lien[6]

1. Graduate Institute of Mathematics and Science Education, National Pingtung University, 2. Department of Science Communication, National Pingtung University, 3. Graduate Institute of Science Education, National Changhua University of Education, 4. Department of Science Education and Application, National Taichung University of Education, 5. Department of Biology, National Changhua University of Education, and 6. Department of Science Education, National Taipei University of Education, Taiwan

ABSTRACT Renovation of science education is underway in many major countries throughout the world. In East Asia, new national science curriculums are currently under developing or implementing in many regions/countries too. Taiwan, with its vital educational system, is encouraging science educators to develop diverse teaching and learning approaches to support the needs of future education. This symposium is organized by Association of Science Education in Taiwan (ASET). Six studies were invited to this symposium to highlight their experimental approaches for facilitating students' learning of science. These six presentations are: 1. Students' Use of Scientific Words in Two Teaching Approaches: Professors Sheau-Wen Lin & Mei-Hsiu Chen explored and compared students' use of oral scientific words in two different teaching approaches—general teaching and inquiry teaching. Two 5th grade classes were chosen as cases. Class observations and related documents were collected from a unit, "Sun Observation". It was found that students who received the inquiry teaching approach used more scientific words (2.5 times), had higher frequency of usage(2.7 times), showed more high-level scientific words, and got higher scores in science achievement than students receiving general teaching approach. 2. Promoting Science Learning through Embedding Reading Instruction: Professor Jing-Ru Wang helped teachers to develop a coherent model of pedagogical designed to facilitate student develop understanding of scientific literacy through the process of reading. The participants included five science teachers and their students of elementary schools in southern Taiwan. The participant teachers were instructed to write and revise a content related text as well as design and enact teaching. The effective teaching methods used included (1) asking questions, drawing or playing card to elicit and change students' thinking and misconception, (2) probing students responses and giving students clear feedback about their ideas, (2) using drawing, mind map, summary skills, and analyzing text structure to improve reading comprehension. 3. Experiences of Designing and Implementing Model-based Instruction in Taiwan: Professor Silvia Wen-Yu Lee will share his experiences of designing and conducting research of model-based instruction in Taiwan. Two middle-school level units, one in earth science and one in environmental science, were developed and implemented. Through concept mapping and drawing, students showed improvement of modeling competence. Students' understanding of models and modeling was also examined and compared across the two units. 4. The Narrative Analysis of Science TV Programs and News: Professor Sung-Tao Lee put his efforts on connecting science popularization TV programs and news with science instruction for possible future needs while developing curriculum and instruction. He studied how stories or ideas of science are represented in these science communication platforms. The narrative analysis of the case science TV programs shows that the five major related elements are: (1) motivation and purposes, (2) questions and hypothesis, (3) experiment and method, (4) result and explanation and (5) connectives. Within science news, claims appeared to be the most often used element compared to other elements as representation, experiment, suggestion, causation, examples, misconceptions and definitions. 5. Serious Educational Gaming Facilitates Student Science Learning: Professor Meng-Tzu Cheng

investigates the effect of gaming experiences and the interactions between players and virtual environments on middle school students' science learning outcomes. The results revealed: (1) The students did learn by playing serious educational game, and their long-term knowledge retention was promising; (2) Serious gaming provided students with the experience of immersion insofar as the students indicated a greater degree of immersion in the game over time; and (3) The in-game behaviors and the use of in-game characters were related to gaming performance, which subsequently influenced learning outcomes. 6. Promoting Students' Learning by Using a Self-developed Educational Application: Professors Yu-Ling Lu and Chi-jui Lien explored how to use App to facilitate elementary students' learning. The study designed and developed an assessment-based App which using a competition, yet collaborative learning approach. Then, students' learning effectiveness was examined. Results indicated students who have used the educational App during their learning process showed significant learning improvement. In addition, this learning App also keeps students thinking on a constant basis and makes learning more interesting. These studies share some potential approach in promoting students' learning which have been explored in Taiwan. We are looking forward to having science educators from Taiwan and any parts of the world to meet and to discuss what the future learning should look like and how we, as science educators, could help to reach a better science education for tomorrow.

[27SS2K] Fostering the Scientific Mindset (*A0008*)

Kei Kano[1,2]*+, Shinichi Takeuchi[3]*, Takayuki Shiose[4]*, Eri Mizumachi[2]*, Hiroaki Isobe[5]*, Shotaro Naganuma[5]*, Kensuke Shiga[6], Shingo Ohno[7]

1. Graduate School of Education, Shiga University, 2. Institute for Integrated Cell-Material Sciences (iCeMS), Kyoto University, 3. NHK Educational Corporation, 4. The Kyoto University Museum, Kyoto University, 5. Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, 6. DIRECTIONS, Inc., and 7. Freelance Art Director, Japan

ABSTRACT The knowledge about science which includes the scientific methods or mindsets has been regarded as an important aspect of scientific knowledge in the Programme for International Student Assessment (PISA) conducted by Organization for Economic Co-operation and Development (OECD). In Japan, both knowledge of science and knowledge about science has been included in the national curriculum. However, in Japanese schools, they teaches more knowledge of science and less knowledge about science. It may sound like a contradiction but it shows that Japanese traditional education or entrance examinations has more emphasized the knowledge of science. In this situation, Japanese government will revise the national curriculum in order to foster the more innovative persons in 5 years. The next generation of curriculum would promote more active learning and scientific methods or mindsets, but it would be difficult to proceed the reform because of less teaching methods, contents or materials on knowledge about science developed in Japan, even in the world. In this symposium, we will present various activates toward fostering students' scientific mindsets. First, we will introduce Japanese TV programs, "Think Like a Crow –The scientific methods-" since 2013 and "Viewpoint Science," since 2015 produced by Japan Broadcasting Corporation, Nippon Hoso Kyokai (NHK). These have taken scientific topics and offered scientific questions more relevant to our lives. One of the features of these programs were that they NEVER offer the answers so that audiences could try their own scientific methods or mindsets. However, there have been a lot of feedbacks from the audiences that want audience-friendlier manner. Therefore, we have offered opportunities to help audiences to solve the questions. We will show the workshops to foster the scientific mindsets, using TV programs, "Think Like a Crow –The scientific methods-" and "Viewpoint Science," and the result of an evaluation of them. Finally, we will introduce the workshops on stem cells or space, using board games which scientists have developed for fostering scientific mindsets or promoting understanding of scientific research. Through this symposium, the audiences will learn more about how to implement educational programs on scientific methods or mindsets and evaluate them in schools or informal learning settings.

WORKSHOPS

Workshops 1 (26th, 16:30-18:30)

[26W1C] Lesson Ideas on Integrating Student Learning and Thinking Experiences in School Science (*A0378*)

Tan Kok Siang
National Institute of Education, Nanyang Technological University, Singapore

ABSTRACT School science is often taught as separate subjects like Biology, Chemistry, or Physics. Sometimes it is also taught as an integration of these and other subjects, like Earth Science (integrating with subjects like Geography and Geology), the Life Sciences (mainly Biology and Chemistry) or the Physical Sciences (mainly Chemistry, Physics and Mathematics). Thus, integrating student learning and thinking in science lessons is not a new concept. However, merely teaching science as an integration of a few subjects is less likely to be effective in preparing students for the integrated nature of science- and technology-related problems in real life. Some of these problems may also involve socio-emotional aspects of life. School assessment often influences how students would think and what they would learn in order to do well at the examinations. A more divergent approach to learning science could be more effective but this will also make assessment of student learning more difficult to administer, especially in terms of reliability and fairness. The aim of this workshop is to share and suggest effective lesson ideas that continue to have a focus on preparing students for school assessment but at the same time provide them with enriching learning and thinking experiences in school science. Participants will be introduced to the various concepts related to integrating student learning and thinking in school science and how these concepts may be applied in designing a suitable pedagogy to help student learn science while also mastering the skills of acquiring, appraising and meaningfully using relevant information and knowledge (McTighe, 2010). There will also be demonstrations of lesson ideas, including actual lesson ideas conducted by some Singapore science teachers, on (i) how an established science education pedagogy, like analogies, may be used to integrate student learning of science in the different learning domains (for example, in the cognitive and affective domains), and (ii) how science curricular materials and assessment items may be used as teaching and learning resources in hands-on science lessons that are supportive of the integrative learning objectives of STEM Education. The lesson ideas presented in this workshop are mainly suitable for implementation in primary and secondary school science lessons.

[26W1F] Study of Static Electricity Using Fly Stick (*A0056*)

Noriyuki Nishiyama*+ and Shuichi Yamashita*
Kazusa High School and Faculty of Education, Chiba University, Japan

ABSTRACT 1. Objective There are a lot of phenomena surrounding us which we can explain with the use of scientific knowledge. One of the examples is the presence of static electricity especially during the winter season. I think everyone has experienced that annoying electrical pain when touching a door of a car. If the knowledge the students learn in a scientific class is useful for solving this kind of phenomenon in our daily life, probably more students would become more interested in science. Moreover, if we have the class focused on hands-on study through experiments, the student must feel the joy of leaning. However, static electricity is featured only as an introduction about electric current. Aside from that, sometimes the experiments on static electricity may fail due to temperature or humidity. So, I devised a learning program using the toy (Fly Stick) which causes static electricity based on the principle of Van de Graaff generator. In this program, everyone can easily generate static electricity and students can be proactive in the experiment. 2. Method 1) Making use of Fly Stick as a teaching material Fly Stick is an educational toy which we can easily buy through mail order. With two AA-sized batteries, it can easily generate static electricity which is almost 15KV. Moreover, we can do the experiment without worrying about the humidity even when it's drizzling. Although it is ideal if we can have one Fly Stick per student, it would be enough to have one Fly Stick for every small group of about four. 2)Learning program on how to discharge static electricity safely I assume the time we can spend for the study would be a maximum of 3 hours. Therefore, I have narrowed down the theme to 2 points: one is that human bodies can accumulate static electricity, and the other is how to discharge the accumulated static electricity without pain. 3. Result I gave a 90 minute lesson to 98 sixth grade students at Kisarazu City Jozai Elementary School on February 2, 2016. The below is the summary of the questionnaire conducted after the class: How do you feel about the class? Very enjoyable: 97, Enjoyable: 1, Neither enjoyable nor boring: 0, Boring: 0, Very boring: 0 Do you think the study of static electricity is useful for your daily life? Very useful: 74, Useful: 24, Neither useful nor useless: 0, Useless: 0, Very useless: 0 4. Summary Through this program, students feel that the knowledge they learned in the class was useful for our daily life. In addition, there were many comments about the fun of learning in the free-description-type questionnaire. It was found that the experiment of static electricity using Fly Stick is likely to succeed and is safe for everybody. [Draft]

[26W1G] Learning Scientific Practices through Video Games (*A0492*)

Onur Imren and Sibel Erduran
University of Limerick, Ireland

ABSTRACT This workshop aims to demonstrate how popular video games can be used in educational context. Our specific goal is to emphasize that there is a great deal of commonality between playing a video game and doing science in terms of practices employed. Therefore, we focus on scientific practices based on the Family Resemblance Approach model to the Nature of Science (Erduran & Dagher 2014; Irzik & Nola 2013). Experimentation, classification and observation will be some of the scientific practices which is going to be focal point in this workshop. Workshop will be interactive with 3 popular video games that can be freely played through mobile phones or provided tablets. Participants will have group discussions after the gameplay session. Each video game will be representing one of the scientific practices mentioned above. Group discussions will be around the strategy, decision making and reasoning in video games and their

relationship with the practices that scientists do all the time. At the end of the workshop, attendees will be able to characterise some of the key scientific practices based on the family resemblance approach and they will gain a new perspective towards video games as a tool which can provide an engaging and effective way to learn. Special requests; Timeline: 20 minutes introduction + 15 minutes gameplay + 20 minutes discussion Expected number of participants: 5 – 25 people Instruments needed: A0 or A1 size blank papers and pen, Tablets if its available and a room with plugs. Special note: I will have an oral presentation (A0329) about the theoretical foundation of this study. This is going to be practical application of my study which might be more efficient if it is planned after the presentation. [Draft]

[26W1H] Promoting Minds on Experience When Investigating Yeast Fermentation in High School Biology Laboratory (*A0101*)

Kam Ho Kennedy Chan

The University of Hong Kong, Hong Kong

ABSTRACT High school students often find the concept of respiration difficult. Yeast, a readily available source, offers promising material for studying the topic. In views of this the purpose of this hands-on workshop is twofold. First, it aims at introducing to the participants a low cost micro-scale set-up for investigating yeast fermentation in high school biology classrooms. The second purpose is to equip the participants with useful pedagogical strategies to make practical work in biology more effective. During the workshop, participants will gain hands-on experience of using a simple set-up to investigate fermentation in yeasts. Teaching materials that facilitate students' minds-on and hands-on engagement of the practical work will also be introduced. Pedagogical principles underlying the design of the teaching materials will be discussed. The simple set-up can be readily used in high school classrooms and easily modified for various scientific investigations related to yeast fermentation. The workshop should be of interest to science teachers who would like to improve their pedagogy of designing and implementing effective practical work as well as science educators who are involved in educating high school science teachers.

[26W1I] Development of Science Teaching Tools with Oxygen Sensor using an Air Battery (*A0003*)

Norimichi Kawashima[1]*+, Yoshihiro Hada[2], and Mitsuo Takahashi[3]+

1. International Pacific University, 2. International Pacific University, and 3. Tokyo National College of Technology, Japan

ABSTRACT We have developed an easily prepared handmade oxygen sensor that anyone can easily use using an air battery for science education to measure natural phenomena of oxygen for primary and secondary science classes. This oxygen sensor has very high sensitivity and is both easy to operate and safe as a sensor. The purpose of this study was to develop teaching tools using a handmade oxygen sensor that uses an air battery with which scientific thought and exploratory minds to understand natural phenomena of oxygen can be stimulated. In this workshop, we will introduce the experiments of monitoring oxygen consumption in (1) respiration, (2) candle-combustion, (3) disposable warmers and (4) photosynthesis, as examples of the natural quest-type experiments using the oxygen sensor, Throughout the workshop, we will also encourage participants to share and exchange ideas on other promising experiments using the oxygen sensor. The workshop will be conducted in English, Chinese, and Japanese. [Draft]

[26W1J] Development of a Wildflower Identification Site (*A0165*)

Ken'ichi Saiki[1]*+, Nobuya Hayashi[2], Fumi Nakanishi[3], and Shuichi Yamashita[4]

1. Natural History Museum & Institute, Chiba, 2. Ibaraki University, 3. Tokyo Gakugei University, and 4. Chiba University, Japan

ABSTRACT The present curriculum guidelines of the Japanese government stipulate the observation of living things in the schoolyard and the school's surrounding area. Thus, third grade elementary school students and first grade junior high school students learn about wild plants and insects in their schoolyards. However, many teachers find it difficult to give instructions about observing nature, particularly plants, due to the wide variety of plant species. Usually, more than 80 species of herbs and grasses can be observed in a single schoolyard. The results of questionnaire survey conducted with the science teachers of junior high schools showed that more than 30% of them had weak point awareness in plant identification. To solve this difficulty, we developed a website enabling teachers and students to identify wildflowers. The site includes about 180 species of grasses and herbs common in Japanese schoolyards, and it allows compound retrieval. Teachers can identify plants' names based on the shape and color of their flowers, leaves, fruit, and stem conditions. We designed the website such that it would be usable even with a lack of botanical knowledge. One of the tools we prepared for the site was photograph set of extended plants on a white background. Our study revealed that photographs of this style produced better identification. In the workshop, participants could identify the wild herbs with a prepared tablet PC or their own smartphones. Since the English and Japanese editions of the site are already operative, they can be used anytime on devices connected to the internet. The URLs of the Japanese and English edition sites are as follows:
http://chiba-muse.jp/wf2014/
http://chiba-muse.jp/wf2016e/

[26W1L] Hands-on Static Electricity and Dynamic Electricity Generation (*A0626*)

Michal Marcik

NARIKA Corporation, Japan

ABSTRACT It is difficult to confirm theoretical concepts of electric energy because electricity is invisible to our eyes. One of the ways to overcome this problem is to conduct hands-on experiments and by undergoing the experiments deep understanding of the unseen is expected. In line with historical development we will first start with hands-on experiments with electrostatics. We can generate static electricity by friction of 2 materials against each other (triboelectric effect) and by using innovative small hand-held generator (portable Van Der Graaf generator) continuous static electricity is possible. We will carry out

many experiments, with focus on safety and easy comprehension, no matter how humid weather will be. Example of experiments: attractive and repulsive force, various ways of discharge, etc. After that we will move on to dynamic electricity and learn about electricity generation and from where it comes from. Together with original hand-held DC generator that will be used to electricity generation by the participants. At first principle of the electric motor will be examined. Then hand-held DC generator will be connected to various accessories and study about energy transformation, energy loss and energy efficiency among others will be carried out. Introduced educational instruments are perfectly suited to do experiments that explain the mechanism of static electricity and dynamic electricity power generation in an easy and engaging way that attracts student's attention. All together in hands-on interactive workshop that is fun and engaging. Target age of students for experiments introduced during workshop is: 12 to 18 years.

Workshops 2 (27th, 16:30-18:30)

[27W2C] Enjoyable Short-Time Science Performances: "*Daido Kasetsu*" (*A0504*)

Koji Tsukamoto[1*+], Noritake Okazaki[2], Yuki Yoshino[3], and Kaya Sakashita[4]

1. Chiba Institute of Science, 2. Tamano Konan High School, 3. Metropolitan Ome Sogo High School, and 4. Nagareyama Otakanomori High School, Japan

ABSTRACT We offer a new idea of enjoyable science performances that enable us to conduct in a short time: from 1 hour to half a day. These are not only making science toys or conducting surprising demonstrations, but also inviting people to scientific thinking. The word "Daido" is from the Japanese word "Daido Gei," which means "street performances." Plans of Daido Kasetsu are designed to be performed at festivals, short-time science lectures, brief science events, or even in the middle of a speech. Different from the real street performances such as juggling, or magic, Daido Kasetsu plans do not require any professional skills. Once you prepare the Daido Kasetsu flip books and some simple tools, anyone can conduct enjoyable science performances. Daido Kasetsu plans are designed to be performed not only in classrooms, but also outdoors for chance customers such as the audience in street performances, targeting a wide range of ages from elementary school children to elderly people. The participants will be asked to predict what would happen as a result of a scientific experiment, and then watch the demonstration to see the result. Some other questions and demonstrations will follow, making the audience familiar with scientific thinking with a lot of fun. Five plans have been created so far, such as experiments of a vacuum, low temperature, static electricity, chemical explosion, and Mechanics. At the work shop, we will demonstrate how to do it for the audience by using the Mechanics plan. Plans of Daido Kasetsu are produced by Luctin Laboratoy (NPO), chaired by Yuji MIYACHI, and developed under the theory of Kasetsu Jikken Jugyo (Hypothesis-Verification- Through-Experimentation Learning System). The theory of Kasetsu Jikken Jugyo was advocated by Kiyonobu ITAKURA in 1964.

[27W2D] New Plan to Teach a Concept of the Lift (*A0531*)

Yoshinori Takeda* and Natsue Miyamoto[+]

Okayama University of Science, Japan

ABSTRACT There are many enjoyable experiments on the lift. However, in many cases, they are used fragmentarily, do not lead to the understanding of the lift. In the present report, a new teaching plan on the lift is introduced. In this plan, some experiments are arranged well, which enables to understand of a concept of the lift. Moreover, in our experience, anyone from the small child to the adult enjoy this plan together. This plan was developed by using the methods of the Hypothesis- Experiment class （Kasetsu）. In addition to the already established workbook of Kasetsu, we try such new theme. In the presentation, we attempts to float the familiar materials (a ping-pong ball, a beach ball, a plastic bottle and so on) by using a dryer or a blower. Through these experiments, we confirm difference between floating or non-floating. In addition, We will also introduces related crafting (the boomerang by paper and so on). We hope to experience this plan for the young teachers of the science and the students who hopes the teacher of science.

[27W2F] What's in the Air?: By Using a Colorimetric Tube (*A0110*)

Masaaki Okuda

GASTEC Corporation, Japan

ABSTRACT The gaseous matter is closely related to human life and also has a valuable role in the industry, but the gaseous matter is mostly invisible and it is difficult to confirm the presence. GASTEC develops and manufactures GASTEC Gas Detector Tubes which can measure such gaseous matters easily and precisely in a quick way. As there is no need for expensive analytical instruments and gaseous matters can be measured easily, GASTEC Gas Detector Tube is introduced in science compulsory textbooks for primary, middle and high schools as an educational tool in curriculum. In this workshop, we introduce some experiments utilizing GASTEC Gas Detector Tubes from various standpoints. Science experiments in accordance with some school textbooks in Japan - How do we use Gastec tubes in classes? - Let's measure gas concentrations in our life - Those gases are generated from those goods! Aren't they dangerous? - Proof of the "gas constant" by experiment - Let's prove the common knowledge of high school science! -

[27W2H] Simple and Beautiful Experiments X by LADY CATS and Science Teachers' Group (*A0152*)

Kyoko Ishii[1*+], Masako Tanemura[2], Haruka Onishi[3], Fumiko Okiharu[4], Asako Kariya[5], Mari Satoh[6], Yuuri Kimura[7], Yumi Takano[4], Kasumi Endo[8], and Hiroshi Kawakatsu[9]

1. Tamagawa University, 2. Osaka Kyoiku University, 3. Higashiharima High School, 4. Niigata University, 5. Hosei Daini Junior & Senior High School, 6. Mita International School, 7. Ohyu Gakuen Girls' Junior & Senior High School, 8. Niigata Meikun Senior High School, and 9. Meijo University, Japan

ABSTRACT LADY CATS (LADY Creators of Activities for Teaching Science) is an organization of predominantly female science teachers from all levels of the educational system in Japan - from primary school to university. It was founded in 2004 and they have performed the workshop "Simple and Beautiful Experiments" at several international

conferences since 2005. In recognition of their contribution to international physics education, they were awarded the ICPE (The International Conference on Physics Education) medal in 2012. Recently we have opened our website [3]. The URL of our website is; http://www.osaka-kyoiku.ac.jp/~masako/exp/ladycats/index.html. The aim of our activities is to encourage students and teachers who are not good at physics. Usually female students in Japan are less interested in Physics, and they do not take physics lesson in high school or in university. Therefore, female physics teachers in educational field are few in Japan. On the other hand, there are many female teachers at primary schools. They feel uncomfortable to teach science, especially physics field. In order to change this situation, we have formed LADY CATS since 2005. It is important to show how women are enjoying physics. LADYCATS build on the word of an earlier Japanese teachers group known as the "STRAY CATS" who demonstrated many experiments at international conferences for more than 20 years. We follow their belief that of "Everybody has a right to learn physics". Our concepts of experiments are follows: the "simple" experiments which the teachers in the world including Japan can easily utilize by their lesson, the "beautiful" experiments which children get interested, and the "essential" experiments which can demonstrate the principles of physics. We have performed workshops "Simple and Beautiful Experiments" in several international conferences. In these workshops, we demonstrated and explained our experiments and the participant made the experimental device from the material that we had prepared. The experiments we preparing are; Papercraft balance beam scale, Surface Tension Science, 3D Hologram, Sweet rattleback spin reversal, Paper Chromatography, Pop-up card using mirror sheet, A Simple Speaker, Faraday Motor, etc. If you would like to make them, please attend our workshop. We believe these issues would be a great first step to changing young people's perception of physics.

[27W2I] Hands-on Activities of Materials Based Science Education (*A0250*)

Masahiro Kamata[1*+], Masafumi Watanabe[2], Ayaka Yanase[1], Keita Chiba[1], Koyo Oka[1], Shino Iwashita[1], and Menggenquimuge[1]

1. Faculty of Education, Tokyo Gakugei University, and 2. Faculty of Education, Hokkaido University of Education, Sapporo Campus, Japan

ABSTRACT Materials Based Science Education (MBSE) is a concept proposed by the author, Kamata. In every education, both teaching/learning materials and teaching methodology are equally important, and MBSE does not deny this balance. The only claim from MBSE is the quality and variety of good teaching/learning materials they use in school science. Since we usually put emphasis on hands-on activity in school science in Japan, "Materials" indicates something practically useful in hands-on activities of the students. In this workshop, we will present several kinds of teaching/learning materials developed in Kamata Lab during these 20years so that participants can experience hands-on activities using them. The most of the teaching/learning materials were developed for elementary and secondary school science and some of them are as follows; - EnePick: A tiny tool using LEDs and a capacitor for teaching energy conversion between light and electricity. - ROV(Revolution of Venus): Paper craft for teaching phase of Venus and why Venus changes the moving direction on the celestial sphere. - MiniLight: A small torch using an LED and a lithium cell. MiniLight is effective when teaching basics of electric circuit, electric conductivity, mixing of color of light and fluorescence. - Si-Po: A pump made of silicone-rubber tube. Si-Po is useful in teaching mechanism of a human's heart (or a pump), especially the role of valves in a heart.

[27W2J] Developing an Improved Model of Moon Phases for Secondary-level Science (*A0039*)

Shuichi Yamashita[1*+], Hideki Itou[2*], and Yoshiaki Shimono[3]

1. Faculty of Education, Chiba University, 2. Waseda Secondary School, and 3. Crafteriaux Inc., Japan

ABSTRACT Japanese course of study for elementary and secondary schools which was announced in 1999, did not include the moon phases in its contents. However, the course of study has included moon phases since 2008. Therefore, Japanese university students and young teachers who had been taught under 1999 course of study were had never learned moon phases when they were in elementary and secondary school. For this reason, we had to improve new teaching materials and strategies to assist them in their teaching skills and scientific understanding. The original model was made for elementary level science, and had good points: (1) three-dimensional, which makes it easier to understand the location of planets, (2) easy to understand where the moon and the sun are in each moon age, and why the moon shows up in the shape we see from the earth, (3) inexpensive to buy for all of the students in your class. However, the original model had to be improved for secondary level science. We investigated how it facilitates their understanding of the real cause of moon phases. In this workshop, we are going to report the effects of the improved model, followed by making them by yourself. We investigated how the improved model facilitates their understanding of the real cause of moon phases. At the pre-test, a total of 21 (63.6%) university science students, 49 (86.0%) elementary school teachers and 86(33.6%) junior high school students could not explain the cause of moon phases. However, after using the improved model, all of the university science students, 55 (96.5%) elementary teachers and 235(91.8%) junior high school students were able to explain the same, more completely than the textbook.

[27W2L] A Study of Training Students' Critical Thinking Ability in Biology Teaching in Middle School (*A0084*)

Meifang Li*, Lusha Ji, and Jiahui Hu+

College of Life Science, Liaocheng University, China Mainland

ABSTRACT The innovation oriented education is one of the important goals of the current basic education. Critical thinking is the core of innovation oriented education in middle school. Critical thinking means thinking logically and developing an ability to ask questions. Critical thinking has been defined many ways (Abrami et al., 2008; Rousseau, 2012) and is often described in association with problem solving and decision making. Lovelace et al. (2016) define critical thinking as the ability to thoughtfully analyze and evaluate situations and recommend courses of action that consider stakeholders, implications, and consequences. In the paper, we focus on the pathway of training students'

critical thinking ability by instruction experimentation and document analysis method. The firstly, Teachers must realize the important of critical thinking and improve ability by literature analysis. The secondly, Pre- and posttest student data were collected and used to test critical thinking skills learning. Students performances were actively promote independent, cooperative inquiry approach to learning in classroom. Teachers, as the participants, organizers and leader, participate in teaching process, and carry on equal dialogue, realize the thinking and emotional communication between teachers and students' communication. Let the student positive thinking, bold question, this is extremely advantageous to cultivate the critical thinking of student. The lastly, the effective action is reform of biology teaching evaluation. The evaluation ways lead to a certain extent of basic education reform orientation and directly decides students' learning mode and way of thinking. The grades of critical thinking ability in the experimental group were significantly higher than those in the control group with the difference being statistically significant. We may conclude that it is effective measures for developing critical thinking skills in a child through the right critical thinking training.

DEMONSTRATIONS

Demonstrations 1 (26th, 16:30-18:30)

[26D1X-1] The Practice of Learning Platform' Personalized Learning Resources Pushing System (*A0293*)

Jian Guo* and Zhe Li+

Tokyo Institute of Technology, Japan and Shaanxi Normal University, China Mainland

ABSTRACT Undoubtedly, Big Data and data analytics have a significant role to play in the future of higher education. The growing role of analysis techniques and technologies in government and business sectors affirms this trend. In education the value of analytics and big data can be found in the educational platforms and Mooc including Coursera, edX, udacity enables innovation of teaching and learning in not only K12, higher education, vocational education but other education sector as well. Every day, those kinds of online educational platforms record various massive data about teaching and learning information such as personal status, exercise scores, learning time, learning progress and so on. In this paper, we propose a method based machine learning algorithms to analyze underlying patterns in order to predict student outcomes such as dropping out, needing extra help, or being capable of more demanding assignments using data mining and data analytic the Big Education Data. This method provides immediate feedback to students and teachers for improving their academic performance. We used education data of XXX from YYY company as our experiment dataset to performance the results of our method. [Draft]

[26D1X-3] Inertia Experiment Device & Huge Scaled Dynamics Carts (*A0168*)

Yuhei Gomi*, Shun Iimura*, and Yasufumi Kawamura+

Tokyo University of Science, Japan

ABSTRACT It is well known that students, even after finishing their learning in physics classes, still have problems in the understanding of 'inertia' correctly. Physics teachers have been struggling the issue how to guide their students to better understanding of 'inertia.' In order to help the students' understanding, we believe that it is helpful for the students themselves to 'experience' (not to 'watch') the linear, constant motion and the linear motion of constant acceleration by getting on a kind of huge cart. We developed two types of experiment devices for this purpose. For these several years, we tried to use these devices at various occasions, for example, a mini-science show in informal settings, as well as in school settings. Empirical data indicated that the learners and the audience, who were actively involved in the experience of getting on the cart, showed higher learning outcomes (Kawamura, 1996; 1998). In this demonstration session, we will provide to the audience an opportunity to experience running on the huge cart, we developed.

[26D1X-5] Original Bicycle Dynamo (*A0218*)

Shota Kitahara*, Taiki Machinaga*, and Yasufumi Kawamura+

Tokyo University of Science, Japan

ABSTRACT Global environmental issues are one of the common topics the Japanese public shows their serious

concerns. In school settings, various kinds of efforts have been made by practicing teachers beyond the barrier between subject areas. The topic is treated across the curriculum (science, social studies, home economics, language, integrated curriculum etc.). However, learning activities substantially based upon 'experiment' are still rare. Original Bicycle Dynamo is such an experimental apparatus we developed for learning by doing. The aim of the activities is that students become aware of an alternative way to reduce purchase of electricity (generated by power plants) by doing experiments with Original Bicycle Dynamo by themselves. The Original Bicycle Dynamo, we developed after several revision processes (Kawamura, 2012), enables a large-screen LCD TV to watch or an air-conditioner to work. It serves as a good experimental tool for energy and environmental education in general for the younger generation, whereas it serves as a health equipment for adults if they use it alone for watching TV programs. In our demonstration session, the audience can enjoy Original Bicycle Dynamo for watching TV programs.

[26D1X-7] Comparative Studies on Characteristics and Performance of Savonius-type Desktop Windmill Power Generators (*A0280*)

Hiroki Ninomiya*, Shion Mizutani+, and Yasufumi Kawamura+
Tokyo University of Science, Japan

ABSTRACT After the Great East Japan Earthquake (March 11, 2011), which drew public's attention to energy issues, natural energy has been spotlighted more and more frequently. Energy and environmental education to deal with these issues has also become more important. So far, in the Kawamura Lab of Tokyo University of Science, we have been developing and utilizing several models of Savoniou-type windmill wind power generators (Kawamura 2002, Kawamura et al. 2008, Kawamura et al. 2010, Kawamura et al. 2011, Kawamura et al. 2012, Kawamura et al. 2013, Izutu 2014) as energy and environmental education materials. Among them, this study aims at comparing characteristics and performances of four models with one another, in order to select the most appropriate model suiting to the particular purposes of use. The first model developed in 2008 uses plastic shampoo bottles as the wing of the windmill (bucket). It enabled LEDs to light by using a commercially available motor and accelerating by a rubber band and pulley. It was made of cheaper and easily available materials and lighted an LED. It started generation from a wind velocity of 2.5 m/s, and generated 2.64×10^{-5}W at a wind velocity of 4.5 m/s. The second model adopted a hand-made generator made of coil and magnet. Compared with the former one, this model could successfully light an LED without increasing the energy production. In the case of the previous model, it was difficult to adjust tensions of a rubber band, and sometimes happened was idling of the motor. Also friction between a rubber band and the axis of the motor caused a loss of energy. Another merit of this machine is that by making a generator by themselves, they could easily understand the inner structure of the generator. And they also observe the inner structure of the generators. It started generation from a wind velocity of 1.0 m/s and under a wind velocity 4.5 m/s, it generated 5.24×10^{-3}W. The Izutsu 2014-ONTABLE model (the third model) was an improved one of Izutsu 2013-ONTABLE. While the 2013 model utilized a powerful but expensive neodymium magnet, the 2014 model used a cheaper (100 JPY) neodymium magnet. The 2013 model adopted a rod antenna as a rotating shaft, and at its bottom a cut-out metal part was equipped. But processing of this metal part was not easy. In order to cope with this problem, the 2014 model adopted an iron spit as a rotating shaft. Thus the 2014 model started generation from a wind velocity of 0.1m/s, and generated 48.43×10-3W under the condition of 4.5m/s. The fourth was a Savonius-type desktop windmill power generator equipped with a flywheel. It utilized a bucket with more efficient overlap ratio, which was printed by a 3 D printer. Also, since the bucket of the Idutsu2014-ONTABLE (the third model) was aluminium plates, we must be careful about a risk of injuring fingers. In order to cope with this problem, this desktop windmill power generator adopted a plastic corrugated board, thus much safer than the previous model. The flywheel increased the efficiency of power generation in high speed. It started generation from a wind velocity of 0.5m/s, and generated $39.86\text{x}10^{-2}$W under the wind velocity of 4.5m/s. From the above comparison, selection of windmill will depend upon the situations, for example, usability of a 3 D printer at hand, technical skills to process an aluminum plate, the availability of cheaper materials.

[26D1X-9] Demonstration Machine of Global Warming (*A0166*)

Yoshiyuki Oda*, Hirohiko Sugimoto*, and Yasufumi Kawamura+
Tokyo University of Science, Japan

ABSTRACT Global warming is one of the serious problems in our contemporary society. In the context of energy and environmental education, this is an important topic to be dealt with. Not only lecturing or simulations, but also a certain kind of experiment is appreciated. From this point of view, we developed a machine demonstrating possibility of global warming caused by greenhouse effect gas. The machine consists of two Earth models containing either ordinary air or CO_2 , which are heated by infrared lamps respectively. Not only CO_2, but also CFCs, butane, or aerosol can be used for the experiments. The experiments give students (from elementary to college level students) an opportunity to discuss empirically and scientifically the global warming issues by comparing the effect of greenhouse effect gas with that of ordinary air. So far, empirical evidence showed that the experiments gave positive effects on the students' awareness of global warming issues and on their motivation to do (not to think or discuss) something by themselves (Kawamura, 1999; 2000; 2003; 2004; 2011). In the demonstration session, we will show the audience how to use the machine and how to extend its educational potentials.

[26D1X-11] Simple Enzyme Kinetics Experiment using a Tablet Camera and Urine Test Strips (*A0375*)

Sho Fukaya*+ and Masaharu Takemura
Graduate School of Mathematics and Science Education, Tokyo University of Science, Japan

ABSTRACT A picture taken with a digital camera includes color data by pixels. Color analysis can be performed to measure intensities of red, green, and blue. Therefore, a digital camera can be used as a rudimentary luminous

intensity meter. Nowadays, with the spread of smartphones and tablet computers, high-performance digital cameras are readily available. Color analysis using tablet cameras can facilitate to develop experiments by students. This study aims to design a new experiment for students using a tablet camera. We develop a new web app for using tablet camera as rudimentary luminous intensity meter. And we analyzed color changes of a urine test strip, a diagnostic tool used for urinalysis, using this application. The urine test strip is used for diabetes diagnosis by the detection of glucose in urine. The strip changes color by an enzymatic reaction in the presence of glucose, allowing the quantitative analysis of glucose in solution. Consequently, urine test strips show changed intensity of red depending on the concentration of glucose. However, the intensities of green and blue remained unchanged. Results show that the relation between the concentration of glucose and the luminous intensity of red reflects the relation between the concentration of substrate and the enzymatic reaction rate. A simple experiment for enzyme kinetics could be developed using a tablet camera and urine test strips.

Demonstrations 2 (27th, 16:30-18:30)

[27D2X-1] New Experiments in Organic Chemistry for High School Chemistry Classes (*A0202*)

Masayuki Inoue*+
Tokyo University of Science, Japan

ABSTRACT New experiments as teaching material about organic chemistry which has been developed in our laboratory will be demonstrated with posters, photos and movies. 1. Metal reagent and catalyst supported on chitin or chitosan: gold(III)reagent to detect reductive organic compound or to recognize sugars, gold catalyst in oxidation or reduction 2. Experiments with plant oils: hydrogenation, oxidation, saponification and measurement of iodine values with safe reagents 3. Detection of wide range of esters with modified hydroxamic acid test in aqueous media 4. Some reactions utilizing anionic surfactants: oxidation of benzyl alcohol or benzyl bromide into benzaldehyde, rapid oxidation of toluene into benzoic acid, hydrolysis of benzyl bromide into benzyl alcohol, tin plating on copper 5. Reduction of nitrobenzene under mild conditions These experiments are expected to be useful in general or advanced high school lab class. These reagents and methods are based on the idea of "Green Chemistry". So, it is possible to perform each experiment more safely and cleanly than conventional methods.

[27D2X-3] Dehydration of Terpene Alcohol with Borate Silica Gel as Solid Acid (*A0236*)

Megumi Murata* and Masayuki Inoue+
Graduate School of Mathematics and Science Education, Tokyo University of Science, Japan

ABSTRACT In our laboratory, it has been studied that the borate silica gel (B_2O_3/SiO_2), in which boric oxide is supported on silica gel and solid acid combining borate silica gel with sodium hydrogen sulfate ($B_2O_3/SiO_2+NaHSO_4$). $B_2O_3/SiO_2+NaHSO_4$ functioned as a dehydrating agent, and it created from linalool (smelling lily of the valleys) to limonene (smelling citrus fruits mainly). So we tried to develop an experimental material to learn the pleasure of making something to enjoy the change of fragrance and also to solve the reaction mechanism. This experiment can be used in all academic years of high school. Students in the primary year will feel the intrerest into chemistry by drastic change of fragrance. Students who learned chemistry to a certain level will be interested in drastic changes of carbon skeleton of molecules, and difference in the result of chemical reactions by the component of catalysts. A 30 mL eggplant shaped flask containing 1.0 mmol of linalool, 300 mg of the dehydrating agents (B_2O_3/SiO_2 or $B_2O_3/SiO_2+NaHSO_4$) and a magnetic stirrer bar was heated and stirred in a boiled-water bath for 5 min. Water was added to stop the reaction, and the organic phase was extracted with cyclohexane. The major products were identified by GC / MS (standard material: toluene), and their respective yields were determined. As a result, B_2O_3 / SiO_2 + $NaHSO_4$ created more monoterpenes than B_2O_3 / SiO2. However, with both dehydrating agents, the ratios of cyclic products to acyclic products were almost 8: 2. If other metallic sulfates were used instead of sodium hydrogensulfate, the flavor of products would be full of variety.

[27D2X-5] Development of Remote-controlled Experiments for Online Scientific Investigation: Arduino-based Low-cost Approach and Implications for STEM Education (*A0595*)

Yau-yuen Yeung
Department of Science and Environmental Studies, The Education University of Hong Kong and Centre for Education in Environmental Sustainability, The Education University of Hong Kong, Hong Kong

ABSTRACT Online remote-controlled experiments (RCE) have become an emerging way of providing real-time laboratory practices to engineering and science students in some university undergraduate courses since late 1990s and early 2000s. The main advantages of RCE are that students can conduct experiments at any time and at anywhere for (a) conducting scientific investigation, (b) developing their manipulative skills and/or (c) testing the engineering or scientific principles or models for more in-depth understanding of their limitations and likely errors in a real-life situation. Apart from eliminating the traveling time for coming to the laboratories and fuller utilization of the equipment (at night or during school holidays), the built-in automation system of RCE will usually allow students to conduct experiments with prolonged period of time (over many hours, overnight or even over weeks) which is very essential for certain types of experiments such as charging and discharging characteristics of chargeable batteries, photosynthesis processes of various plants, effects of slow oxidation processes like rusting and chemical corrosion. Despite of the aforementioned educational merits, RCE were implemented in primary and secondary education only as a few research study cases by the authors and other researchers in late 2000s and early 2010s. They have not been commonly adopted in the school sector because of the high cost (around USD10,000 for acquiring the basic RCE facilities and if the famous LabView system from the National Instrument is used), proprietary development software tools and the bulky plugin which is available for some popular platforms like Windows only. Those problems form a very high barrier to deter school science teachers to adopt, apply or develop any RCE by themselves. Recently, the author has successfully derived

some low-cost and easy approaches for RCE development in which the famous open-source microcontroller platform called Arduino is adopted to collect data from various sensors and control the equipment setup. Using the Arduino IDE (Integrated Development Environment) and many sensor libraries and sample source codes available in the public domain, the programming of the Arduino board for specific RCE design is found to be much easier than that using the proprietary software like LabView. For developing the online interface of the RCE, the PHP language is integrated with the Apache web server in a Scientific Linux machine. It can provide not only a free and light-weight solution across almost all common operating systems but also it is normally independent of the chosen browser and there is no need to install any bulky or proprietary plugin. With the hardware cost of less than USD100, a set of RCE for investigating the physical characteristics of lighting devices was successfully developed and a class of students had tried out the relevant experimental activities. Besides, some training workshops were offered to a few project students for enabling them to develop their RCE on their chosen science experiments. Demonstration with findings from the students' learning and development experiences of the RCE and the implications in STEM education will be presented in detail.

[27D2X-7] Using Mobile Science Museum with Immersive VR Exhibits to Promote STEM in China (*A0476*)

Xiaomei Yan*[+] and Zhizhen Zhang
Beijing Normal University, China Mainland

ABSTRACT Promoting STEM education has been explicitly emphasized in Chinese educational policy. However, there lacks competent teachers and resources to implement STEM into science classes in schools. And the imbalanced distributions of the educational resources within China further slows down the process of implementing STEM in schools. In response, the mobile science museum equipped with immersive VR exhibits were designed and expected to bring the equal opportunities to schools for carrying out STEM programs. The mobile science museum provided science education instructors and STEM programmes cross educational levels. Based on the affordances of the VR exhibits, the researchers designed authentic STEM learning programmes for students. The researchers designed the STEM programmes to fit either short lecturers or week-long projects. With the immersive VR exhibits, the students can explore the various virtual worlds within the limited spaces in the mobile science museum. The use of VR technology enables the students to explore the contexts could not be explored in the real world (expanding the space and time zone; or the interesting places with different accesses). The students can conduct observations and even data collections within the virtual world. With other real-world science tools, the students can carry out the data analysis or experiments guided by the instructors. Then the students can create their own virtual worlds to present their study results or test their hypothesis. Within these programmes, the students can experience the nature of scientific inquiry in various virtual contexts. Therefore, this study claimed that using VR technology in mobile science museum makes it possible to bring the quality STEM programmes to Chinese students in any places.

[27D2X-9] A STEM Activity Material using Hayabusa2 Swing-by Data (*A0245*)

Susumu Yoshida[+], Yoshiko Sato, Tomomi Nakaguchi, Miyu Kitamura, and Miyuki Nagashima
Wakayama Shin-ai High School, Japan

ABSTRACT We have developed a STEM activity material for upper secondary school students using Hayabusa2 swing-by data. In the demonstration, we present work sheets and explain the activity using some model materials. Hayabusa 2, a sample-return mission to an asteroid Ryugu, launched by JAXA on December 3, 2014, successfully performed the earth-swing-by on December 3, 2015, which gave the spacecraft a speed to reach the target. The 12m radio dish of Institute for Education on Space, Wakayama University, tracked the craft and monitored the frequency of its signal on the swing-by day. The data is the raw observed frequency. Students have to read the frequency and plot its changing with time. As the craft approaches and goes away, the observed frequency changes due to the Doppler effect. The raw data shows that the change from coming to going away in velocity occurs at around 6:30 – 6:40 pm (JST). On the other hand, according to the data by JAXA, the time must have been around 6:10 – 6:20 pm. Students are asked to discuss the reason. The calculated data by JAXA is what is expected from the imaginary position of the center of Earth. Students have to calculate the correction for observing site difference. The real observing site is on the rotation of the Earth on its axis and the orbital motion around the Sun. The correction calculation needs some geometric consideration. With the correction, students confirm the observed data matches the given data for not only the velocity change time, but also the time the craft is closest to Earth and the direction of the draft from observing site. The activity needs knowledge of dynamics, physics of wave, geometry, graphing, and computer. This material is one example that can be developed in the era of space development, with the radio antenna for transmission to and from the craft, which was developed especially for small satellites by university laboratories. This work has been made with the help of Professor Hiroaki Akiyama, Akihiko Tomita, Masami Okydo and other staff of Institute of Education on Space, Wakayama University.

Oral Presentations

Oral 1 (26th, 11:30-12:50)

<1A> Learners (Teaching/Learning)

Chair: Sonya N Martin (Seoul National University)

[26O1A-1] The Impact of Multiple Representations on Hearing Impaired Students Learning Human Circulatory System (*A0023*)

Jia-Ying Lin*, Chun-Mei Hu, and Mei-Hung Chiu+

Graduate Institute of Science Education, National Taiwan Normal University, Taiwan

ABSTRACT Special education in Taiwan is moving toward a goal of inclusion. Inclusive education provides an environment for both non-disabled and disabled students to interact and to understand each other. But the issue of how to teach the disabled students learning science is rarely discussed. In the field of science education, multiple representational teaching is a good instruction to improve students' scientific concept. The purpose of this study is to investigate the impact of multiple representational teaching on the students with hearing impairment. This research developed a human circulatory system conceptual change course, based on the theory of multiple representations. Forty Grade 12 students participated in this study, 20 students served as the experimental group under the multiple representational teaching system, the remaining 20 students served as the control group under the conventional system. These results show that (1) multiple representational teaching can correct hearing impaired students' misconception; (2) multiple representation teaching can enhance students' interest and motivation; (3) hearing impaired students can elevate the exam score based on the theory of multiple representations. In summary, this study can provide a useful instruction for science teachers and special education teachers to design a suitable course.

[26O1A-2] Pre-service Science Teachers' Changing Perceptions of Science for Students with Special Education Needs Based on Engagement in Practical Science Activities (*A0062*)

Da Yeon Kang* and Sonya N. Martin*+

Seoul National University, Korea

ABSTRACT Until recently, special education needs (SEN) students in Korea were primarily educated in special schools – but now about 70% of all SEN students are being educated in mainstream schools and 25% are being educated in full-time inclusion classrooms. Because teacher education programs and professional development aimed at teaching science to SEN learners is not common in Korea, science teachers are not well equipped to teach these students. This issue is not unique to Korea as there is limited research focusing on content specific teachers' experiences teaching SEN students in the literature. This research seeks to fill this gap by examining the changing conceptions about "inclusive education" of 11 pre-service science teachers' as a result of their participation in an experiential pedagogy course in a science teacher education program for undergraduate students. Using ethnography, we examined 11 pre-service science teachers' changing conceptions about "inclusive education" as a result of their participation in activities designed to have them reflect on their beliefs about the value of inclusive science education for special education needs (SEN) students. The course took place over 15 weeks and includes several assignments designed to promote student reflection in both written form and in small group and whole class dialogue. Data includes interviews, survey responses, and observations from course interactions examining which aspects of the course assignments and experiences positively impact on pre-service teachers' perceptions for teaching science to SEN students. Teacher interviews and autobiographical writings were analyzed to understand the impact of experience on beliefs about SEN students, the value of inclusive science education practices, and teachers' attitudes towards teaching science to SEN students in the future. Our analysis focused on exploring changes in knowledge and beliefs about a) SEN students as learners/ science learners, b) general / science specific inclusive instructional strategies, c) special education and inclusion education laws and policies, d) setting general and science specific learning goals for SEN students, and e) effectively evaluating SEN students. Writing autobiographical reflections to reflect on their personal biases and participating in experiential activities with community members and SEN students were found to be particularly helpful in improving teachers' understanding about 1) what inclusive science education is, 2) what strategies are effective to teaching science to SEN students, and 3) why science instruction is important for all learners. Results from this study will provide important implications for improving this course and will assist in further development of research and teacher professional development for promoting inclusive education practices in science classrooms. We conclude by highlighting which aspects of the course most positively impacted on teachers' perception about the value of teaching science to SEN students and we discuss implications from our research about how to more effectively design curriculum promoting inclusive education practices in science classrooms.

[26O1A-3] An Exploratory Study on Teachers and Culturally and Linguistically Diverse Students in the Korean Science Classroom: Implications for Developing Teacher Education and Professional Development Programs (*A0498*)

Jennifer C. Park*+

Seoul National University, Korea

ABSTRACT Due to changes in Korea's immigrant population, schools are experiencing an influx of culturally and linguistically diverse (CLD) students who may differ from native Korean students with regards to culture and language. Building on the work of Angela Calabrese-Barton (Barton, 2001; Barton & Tan, 2008), documenting and analytically describing people's beliefs and experiences can provide important information regarding the types of practices and policies that schools, teachers, and families could implement to better support CLD students in science classes. This presentation focuses on understanding the challenges Korean teachers and CLD students face when using inquiry-based science practices with CLD students who may have limited Korean language proficiency. Using a mixed-methods approach, this study specifically examines the Korean teachers' attitudes and beliefs about increased

diversity in Korean society and teachers' self-efficacy and outcome expectancy for teaching CLD students using inquiry and language support strategies. Quantitative data was collected from 144 teachers using a three-part questionnaire called the Korean Teachers' Attitudes and Self-efficacy for Inquiry and Language based Teaching (K-TASILT) and qualitative data was collected by interviewing a total of 36 CLD students and families enrolled in Korean public schools. Analysis of the quantitative data provided a broad overview of the attitudes and beliefs of Korean teachers regarding changes in Korean society and offers some insights into how attitudes towards CLD students and families can shape teaching self-efficacy for instructing CLD students using inquiry teaching strategies or language supports. Findings suggested there are several factors that can influence teachers' outcome expectancy for using inquiry and language supports with CLD students. By employing the theories of intersectionality and Sewell's (1999) structure and agency dialectic, the interview transcripts were analyzed to make sense of CLD students' science learning experiences. These lenses encourage researchers to interpret the ways in which science is taught and learned by considering the impact different societal structures (schema and resources) have on participants as they seek to access and appropriate resources (like textbooks or scientific language) to effectively meet their goals of learning science. Of particular interest to this study was a focus on understanding how intersecting factors (such as race, ethnicity, social class, nationality, or gender) shaped teachers' and CLD students' attitudes and beliefs towards school or science and how these intersecting factors limited or afforded different groups of students access to the resources needed for them to be successful in school. The interview analysis provided some context for understanding how Korean teachers' reported attitudes and self-teaching efficacy could potentially support or limit CLD students from being successful in school and science. Specifically, this research found that different intersecting categories (like ethnicity, native language, and economic class) can impact how successful different CLD students may be in school and in science. These findings are used to offer implications for developing science teacher education programs and professional development for pre- and in-service teachers focused on diversity, multicultural education, and inquiry-based science strategies for supporting CLD students and their language development.

[26O1A-4] Action Research as a Professional Development Model for Supporting Teachers to Improve Science Teaching and Learning in Diverse Classrooms (*A0507*)

Jennifer C. Park*, Hee Kyung Park*[+], Yoon Su Cho, Ju Yeon Lee, Lina Lee, Hee Soon Park, and Sonya N. Martin
Seoul National University, Korea

ABSTRACT The current demographic trends in Korea are shifting and for the first time teachers are in the position of teaching culturally and linguistically diverse (CLD) students. However, teachers are not adequately prepared to support CLD students' science content learning and second language acquisition in their classrooms. At the same time, there is increased emphasis on inquiry-based science teaching and learning, which could limit CLD students from learning science because many lack the language proficiency to effectively communicate and understand scientific concepts. This study focuses on describing an action research model using cogenerative dialogue and video analysis as tools to help teachers and CLD students collaboratively identify problems and develop teaching strategies designed to improve their science teaching and learning for CLD students. The research focused on the development of a collaborative action research project with a science teacher and students from her class in which they use video analysis and cogenerative dialogues (Roth & Tobin, 2001; Tobin & Roth, 2006) to reflect on and make changes to the teaching and learning in their science class. Data was collected at a public middle school near Seoul that has been designated as a multicultural preparatory school due to large numbers of multicultural students living in the region. In the first phase of the action research project, the researchers used the Reformed Teaching Observational Protocol (RTOP) and the Sheltered Instruction Observational Protocol (SIOP) to analyze three science lessons to provide a baseline score to evaluate the teachers' general inquiry-based instruction and language teaching practices. These scores were used to generate discussion with the teacher about her teaching practices and to have her choose which items she wanted to target for improvement. After selecting some items, the researchers and teacher designed some plans for implementing strategies to support CLD students in class. In the second phase of the research, the teacher implemented some changes in a lesson, which we recorded and analyzed. We then invited students to join in a cogenerative dialogue session to reflect on their teachers' new strategies and to evaluate the effectiveness of the teachers' changed practices on students' science and Korean language learning, especially for CLD students. The teacher and students discussed the changes and made suggestions to implement in a follow up lesson, which was also recorded, analyzed and discussed in a second cogenerative dialogue with the same students. We engaged in this cycle 2 times (6 lessons and four cogenerative dialogue sessions). We share findings from the teacher and students about the effectiveness of reflecting on video from their own class and engaging in dialogue about their practices as a useful method for effecting positive changes in the science classroom. We conclude by discussing the benefits and challenges of engaging teachers and CLD students to collaboratively engage in action research designed to improve science teaching and learning.

<1B> Teachers

Chair: Miku Yoshida (University of Copenhagen)

[26O1B-1] Exploring Physicists' and Chemists' Views of Scientific Models (*A0138*)

Meng-Fei Cheng[+], Chia-Yuan Lu*, I-wen Huang[+], and Yu-Ju Hsu[+]
National Changhua University of Education, Taiwan

ABSTRACT Research shows that students have different understandings of scientific models in chemistry and physics; however, there has been no research to indicate the nature of this difference. To address this, the aim of this study is to explore the similarities and distinctions between views of scientific models. Ten physicists (include Theoretical physics, material physics, Cryogenics, Semiconductor Physics & Devices) and ten chemists

(include Inorganic Chemistry, Analytical chemistry, Chemical engineering, Theoretical chemistry, Organic synthesis) from Taiwan participated in this study. Semi-structured interviews were conducted, transcribed, and analyzed to examine three aspects: (1) the nature of scientific models, with examples; (2) the main functions of scientific models; and (3) the criteria of evaluating scientific models. Our study revealed three major findings: (1) Most experts consider that a scientific model serves as a tool, or a method of solving problems. Only a few chemists think of models as exact replicas of target events. The majority of chemists proposed ball-and-stick models as examples of scientific models, but the physicists provided diverse examples, such as the model of the atom, the ideal gas model, and the standard model of particles. (2) Both physicists and chemists believe that, as a basic function, scientific models should include explanations and predictions. Chemists pay more attention to functions which help in understanding and visualizing the concepts. (3) Experts from both groups have similar viewpoints in terms of the criteria of evaluating scientific models. In particular, the physicists proposed that the explanation of multiple scientific phenomena is more important than the other criteria. In our research, the explanatory and predictive functions of models were emphasized by experts in general, but the models were represented differently, by abstract ideas or replicas of target events, according to their purpose. Therefore, our findings lend support to the notion that instruction should focus on the explanatory and predictive role of models and the limitations of different types of models.

[26O1B-2] Science Teachers' Subject Specific Beliefs and Their Approaches towards Professional Development: Curiosity and Interest (*A0542*)

Miku Yoshida* and Jan Sølberg+
University of Copenhagen, Denmark

ABSTRACT Teachers are important to ensure the quality of education. Science teachers have different approaches towards professional development (PD). Studies of PD have recently shifted from a training perspective to a teachers' learning perspective (Bryan, 2012), because beliefs play a role in teaching practices as well as how teachers approach PD. Pajares (1992) has identified six different types of teachers' educational beliefs and one of them is called subject specific belief (SSB). In this study, SSB is defined as beliefs that teachers have about the subject, how it is learned and how it should be taught. This study investigated what kinds of SSB science teachers in lower secondary schools have and if there is any patterns among teachers in Denmark. Semi-structured interviews were conducted with 6 science teachers. Interviews were analysed following phenomenological analysis procedure. The findings implied that Danish teachers' SSB showed the common belief that "curiosity and interest" was important in science education. The reasoning behind this seemed to be that curiosity and interest were the core of what students should learn from science. The teachers SSB indicated that while knowledge or theory got revised over time, curiosity and interest remained as important for students even if society changed, scientific knowledge was revised and/or the students changed careers paths over time. However, there were also differences between teachers' SSB regarding their approach to the students in science classes. Some teachers believed that students either have or don't have curiosity and interest before they start on the science lessons. Others believed that curiosity and interest can be developed during science classes. From the analysis, there were two kinds of relationship between teachers' experience and teachers' approaches. The first point was teachers' personal experiences before they became science teachers and another was teacher's experiences during their career. In this study, teachers who were not good at or chose science paths in their childhood showed more positive attitude towards teaching students who were not interested in science. Because they have established the belief that students' negative attitude towards science can be changed. On the other hand, teachers who had always been into science showed less motivation towards students who were not interested in science unless teachers have experienced when students changed their attitude during learning. This also encouraged collaboration among teachers. It implies that if teachers get institutional support during their teaching, their beliefs can be developed and it results in the positive attitudes towards their professional development. The same interview has been conducted in Japan and its result and cross-cultural discussion will also be presented at the conference.

[26O1B-3] Using a Comics-Based Instrument to Investigate Three High School Teachers' Mathematics Knowledge for Teaching: An Exploratory Study (*A0435*)

Yung-Chi Lin[1] and Hsiang-Yin Yu[2]*+
1. National Hsinchu University of Education and 2. National ChangHua University of Education, Taiwan

ABSTRACT The purpose of this study was to use a comics-based instrument for investigating high school teachers' mathematics knowledge for teaching (MKT; Ball et al., 2008), and to explore teachers' preferences after reviewing both comics-based version and text-based version of the instruments. The comics-based MKT instrument was an adaptation of Lin and Chin's (2014) text-based MKT items, and the mathematics topic of the instrument is about "Lines and planes in space". In all, the former (Lin & Chin, 2014) includes seven items, all written in a similar format: four that test the domain of specialized content knowledge (SCK); two, the domain of horizon content knowledge (HCK); and one, the domain of knowledge of content and students (KCS). In the comics-based version, each of the seven items begins with a comic strip of a teaching scenario, followed by two or three questions regarding the situation shown. The difference between the comics-based version and text-based version of each item was confined to the mode of presentation of the teaching scenarios. A case study method was adopted, and three high school teachers with varying amounts of mathematics teaching experience were recruited. Two of them were in-service teachers with two and seven years of teaching experience respectively, and the other, a pre-service teacher was in the secondary mathematics teacher certificate program at a university of education. The research procedure consisted of first administering the comics-based instrument to all three teachers without any time limitation. Then, their responses were analyzed by two researchers, who also generated questions for further

exploration of the participants' thinking via later one-to-one follow-up interviews, which were conducted one week later. Immediately after these interviews, the teachers were given the text-based version of the instrument. They just needed to look carefully at it and it was not actually administered to them. Then, the teachers were asked to compare both versions, choose their favorite version, and to explain their reasons for this choice. The results indicated that (i) overall, the most experienced teacher performed better on the comics-based version of items than either the pre-service or novice teacher did; (ii) equipped with better knowledge of KCS, the most experienced teacher tended to incorporate her knowledge of KCS when answering the comics-based version of items related to the other, non-KCS domains of MKT (for example, using both KCS and SCK to answer an SCK item); and (iii) the teachers as a group did not have a clear-cut preference for one or the other version. Specifically, the pre-service teacher and the novice teacher preferred the comics-based version on the grounds that it allowed them to better understand the teaching episodes, whereas the experienced teacher preferred the text-based version, stating that it allowed her to figure out the main points of the teaching episodes more quickly. It is therefore suggested that this new method of measuring MKT may have distinct advantages, particularly when testing novice and pre-service teachers, though further research with larger sample sizes is recommended.

[26O1B-4] German and Japanese Student Teachers' Views of Creativity (*A0070*)

Luzie Semmler[1]*+, Verena Pietzner[1], and Shingo Uchinokura[2]
1. Chemistry Education, Institute of Chemistry, Oldenburg University, Oldenburg, Germany and 2. Faculty of Education, Kagoshima University, Kagoshima, Japan

ABSTRACT Creativity is a complex concept without a worldwide-accepted definition. Therefore, there are different understandings of creativity and different methods of measuring and assessment. Calling something "creative" depends on society and its development. Over the past years many definitions of creativity were developed. It was Joy Paul Guilford, a researcher of human intelligence, who initiated the modern creativity research with a lecture on a congress of the American Psychological Association in 1950. In the following years creativity research boomed in the USA. Other countries were less interested in researching creativity. In many European countries and also in Japan creativity is still a neglected field of research (Urban, 1990; Kim, 2005). Nevertheless, creativity gains in importance nowadays, because industry and technologies are dependent on innovations. Society's increasing demand of being creative, is the reason for more and more students have to train this capability in school. Because of that, creativity should be a fundamental part of school education, but it is not, neither in Germany nor in Japan. Creativity only is a mainly part of artistic and handicraft subjects in school. But it is not integrated in other school subjects, especially in science, mathematics, computer science and technics. One reason for that is that creativity is not or only a little part of the German and Japanese curriculums (Cave, 2001; Kim, 2005; Cachia & Ferrari, 2010). To integrate creativity in those subjects, it is important to determine student teachers' and teachers' views and concepts of creativity (Newton & Newton, 2009). This is the purpose of this study. To reach this purpose the authors have developed a new research instrument, which includes making two concept maps and filling in a short questionnaire. There are no specifications for the first concept map, but there are words according to creativity given for making the second concept map. The questionnaire includes, for example, questions about the view of encouragement of creativity, the integration of creativity in the students' own lessons, the integration of creativity in the academic studies, and the students' view of their own creativity. German and Japanese chemistry/science student teachers' views and concepts of creativity have been surveyed and analysed with this research instrument. This includes a quantitative and qualitative analysis of the data, but the focus is on the qualitative approach. Therefore, a particular analysis procedure was developed which is based on the content analysis using categories according to Mayring (2010). In the presentation, the development and the pilot test of the research instrument and the analysis method will be explained. Furthermore, first results of the study conducted in Japan and Germany will be presented.

<1C> Learners (Curriculum/Assessment/Policy)
Chair: Seungho Maeng (Seoul National University of Education)

[26O1C-1] Validity Evidence for a Learning Progression of Scientific Explanation (*A0009*)

Jian-Xin Yao*, Yu-Ying Guo+, and Jie Yang
Department of Physics, Beijing Normal University, China Mainland

ABSTRACT To provide scientific explanation for natural phenomena is a fundamental aim of science (Kitcher & Salmon, 1989), therefore it has been selected as one of the key practices in policy documents around the world (e.g. NGSS Lead States, 2013; MOE China, 2011). Although previous research has made the first step toward a systematic delineating of students' progression in scientific explanation using the Claim-Evidence-Reasoning framework (e.g. McNeill, Lizotte, Krajcik, & Marx, 2006; Songer & Gotwals, 2012), however, further clarification, extension, and elaboration are still called for by researchers (Braaten & Windschitl, 2011; Osborne & Patterson, 2011) and evidence supporting a validation argument for learning progression of scientific explanation is still lacking (Gotwals, Songer, & Bullard, 2012). Following up previous study (Yao, Guo, Neumann, 2015a), which has proposed the Phenomenon-Theory-Data-Reasoning (PTDR) framework for scientific explanation in K-12 education, a two-facet model of learning progression of scientific explanation is proposed. The first facet, complete degree, describes the completeness of the language structure in an explanation (cf. Songer & Gotwals, 2012), while the second facet, component levels, delineates the basic to in-depth levels of each component (e.g. Berland & McNeill, 2010; Perkins & Grotzer, 2005). Fusing the two progress variables, several stages of learning progression have been hypothesized. We then developed the Scientific Explanation Progression Assessment (SEPA) to collect students' performance on scientific explanations. After refining the instrument in two pilot tests, the SEPA was administered to N = 4550 grade 8-12 students from two districts in Beijing, China. Then we combine Rasch analysis (Winsteps 3.74) and other statistic tests (SPSS 20.0) to examine the validity of our hypothesis.

The result of linear regression supports the validity of the PTDR framework, R2 = .790, F(4, 4566) = 4728.83, p < .001. The results from ANOVA (F(4, 55) = 62.28, p < .001) and post hoc comparisons (p < .05) suggest the complete degree is an significant indicator of students' explanation ability. Then an in-depth analyzing on the components finds that the levels of each component are distinct (t = - 4.14, p < 0.001, d = 1.15) and the component phenomenon is easier than data (p < 0.1) and the other two components (p < 0.01). In addition, the Wright map provides empirical clue for the fusing of above progress variables. These results replicate some findings in previous research (e.g. Gotwals, Songer, & Bullard, 2012) but indicate a more elaborated and extended progression pattern. Analyses in this study corroborate the validity of the PTDR framework of scientific explanation and the learning progression derived from this framework. Combined with other learning progression of discipline core ideas and crosscutting concepts (e.g. Yao, Guo, Neumann, 2015b), it can be used as a basic for systematic instructional design integrating multi dimensions of science learning.

[26O1C-2] Science for Citizenship: Developing Butterfly Warriors (*A0078*)

Junjun Chen
The Education University of Hong Kong, Hong Kong

ABSTRACT Given worldwide concern about a decline in student engagement in school science and an increasing call for science for citizenship in New Zealand Curriculum, this study focused on a butterfly unit that investigated how students in a year-4 primary classroom learnt about New Zealand butterflies through thinking, talking, and acting as citizen scientists. The butterfly unit included five lessons. The researchers observed the lessons and interviewed students and the classroom teacher. The students completed a unit evaluation survey after the unit. Findings indicate that the students enjoyed and were interested in activities such as reading about butterflies, learning and using new vocabulary, drawing butterfly life cycles, as well as hunting, tagging and releasing butterflies and publishing the data they had collected on a dedicated website. Through their participation in the unit, students had opportunities to act locally and globally, and to 'see themselves' in science through 'being there' experience. Units like this have the potential to develop students' interest for longer-term engagement in science, even those students who may never envision themselves as professional scientists. [Draft]

[26O1C-3] Examining Students' Concepts of Spinning in Space (*A0599*)

Chi-ling Wu*+ and Chao-ti Hsiung
National Taipei University of Education, Taiwan

ABSTRACT Identifying students' understandings prior to instruction is recognized as a useful method to enhance students' science learning. In this study, we used two tests (TOT: Test of Taiwan, which was designed by Taiwan research team. There are 41 multiple choice questions in it. TOA: Test of Australia which was designed by Australia research team. There are 10 questions, including multiple choice, drawing and writing questions.) to uncover students' understandings of some introductory astronomy concepts. Both tests included multiple choice items and items that required students to construct representations. Seventy-seven fifth graders completed both tests after learning a topic "Star". The students had previously completed astronomy topics on "Sun", "Time" and "Moon". Results showed that most of the students could figure out the relationships between the Sun and shadows at different times during one day on both multiple choice items and items which required a drawn response. But they could not interpret and explain the changes of shadows during the day even though they had observed and learned about the Moon, Sun and stars before. There was remarkable divergence in students' answers to multiple choice and drawing items on the relative sizes of the Sun, Moon and Earth. Implications from the study include the need to use multiple representations in teaching astronomy and to probe students' understanding.

[26O1C-4] Development and Revision of Assessment Items for a Learning Progression in Astronomy (*A0373*)

Seungho Maeng[1]*, Kiyoung Lee[2], Young-Shin Park[3], Jeong-A Lee[4], and Hyunseok Oh[4]
1. Seoul National University of Education, 2. Kangwon National University, 3. Chosun University, and 4. Seoul National University, Korea

ABSTRACT This article addresses how an assessment item set with which examines learning progressions for astronomy was developed and refined through our three-year long study. We have investigated students' developmental pathways of both conceptual understanding and spatial/system thinking on the motions and structures of Earth, Earth-Moon system, Solar system, and Galaxy and the universe. We employed Mark Wilson's construct modeling approach to develop the learning progressions, designed ordered multiple-choice item sets in year 1 and 2, and interpreted students' responses to the items with Rasch analysis. Based on the results of two years' study we obtained a learning progression framework for astronomy. The pathways of learning progressions, however, were constrained by the prescribed hierarchical order of categories of the items. In year 3 we, therefore, sought to revise the ordered multiple-choice items toward two-tier constructed response items. The first tier of items requires describing observation of astronomical phenomena, and the second tiers ask the reasoning behind the description at the first tiers. During the presentation of this study, we will show the details of our assessment items and how we revised the items through learning progression research. Compared with the former learning progression frameworks in year 1 and 2, the study in year 3 included students' various accounts on the responses to the items, which made former learning progression framework revised in more detail. We discuss the outcomes and some challenges to develop and revise assessment items for investigating astronomy learning progressions.

<1D> Learners

Chair: Fang Huang (Huazhong University of Science and Technology)

[26O1D-1] Characteristics of University Students' Explanations Based on the Science Textbooks and Their Self-evaluation: A Case Study of Boyle-Charles' Law (*A0396*)

Cheong Yong Wook

Department of Science Education, Seoul National University, Korea

ABSTRACT Science educators have paid much attention on a recent view of 'epistemic practice' which integrates scientific inquiry with conceptual knowledge instead of separating content knowledge from process knowledge. However, typical styles of usual science textbooks are apt to deliver scientific content knowledge as correct ones instead of dealing with scientists' actual epistemic discourses. This issue of 'delivery metaphor' of science textbooks' should be carefully considered when an instructor attempts to put a high educational value on epistemic practice since the common styles of textbooks could conflict with the view of epistemic practices, which could make students' difficulties. From the recognition of the problem, this study investigated how university students construct explanation of given phenomena and evaluate their own explanations in the context of thermal physics. During the task, they were requested to consult relevant physic textbooks. In addition, we explored the characteristics of university students' evaluation criteria of explanation. 20 University students who attended at the senior level thermal physics course participated in this study. They responded on a written questionnaire dealing with Boyle-Charles' law, an empirical law of thermal physics and carried out small group discussions based on their responses. From the data, the characteristics of university students' explanation and their evaluation are analyzed. We find that task requested to the participants is neither easy nor familiar. On the other hand, students could provide diverse evaluation criteria of explanation, although they did not utilize the criteria spontaneously when they evaluated their explanations. Our findings suggested that their experience of science learning is more relevant to 'delivery of correct information' instead of 'epistemic practice'.

[26O1D-2] A Study on Views of Nature of Science of Undergraduate Students in Science Programs and Its Implications (*A0403*)

Fang Huang

Huazhong University of Science and Technology, China Mainland

ABSTRACT Nature of Science (NOS) has become one of the main issues of science education reform worldwide and a hotspot of science education research. This study evaluated views of NOS of undergraduates in science programs and discussed its implications for science education at college level. This study selected 10 undergraduates majored in science programs in Huazhong University of Science and Technology. Using a mixed method, this study analyzed participants' views of NOS based on data collected from questionnaire of Views of Nature of Science—version C (VNOS-C) and follow-up semi-structured individual interviews. VNOS was first developed by Lederman and O'Malley as VNOS-A and later on was revised and modified into several different forms. VNOS-C was composed of 10 open-ended items and used to assess participants' views of 7 aspects of NOS including empirical nature, tentativeness, difference and relationship between theories and laws, creativity and imagination, inference and observation, theory laden, and social and cultural embeddedness. Follow-up interview was used to clarify ambiguities, assess meanings that respondents ascribed to key terms and phrases, and explore respondents' lines of thinking. Participants' views of NOS were categorized from explicit naïve views if they explicitly articulated their perspectives that was erroneous to explicit informed views if their responses indicated they had a good understanding of NOS. Results indicated that: (1) generally students' views of NOS were between implicit naive level and implicit informed level, (2) they mainly hold a view of positivism, (3) most of them manifested a view of scientism, (4) there was a lack of good understanding of history of science especially development of modern science among research subjects. Accordingly, this study put forward suggestions for science education at college level that: (1) add history of science in textbooks, (2) lay emphasis on students' "doing" and "thinking" in science courses, (3) create more opportunities for students to get in touch with scientists and work in authentic science research settings, (4) teach students knowledge of NOS in an explicit way.

[26O1D-3] Learning Scientific Practices through Video Games (*A0329*)

Onur Imren and Sibel Erduran

University of Limerick, Ireland

ABSTRACT We present a theoretical and systematic overview of some key scientific practices. By scientific practices, we mean the range of practices such as classification and observation that scientists employ in generating knowledge. These are not exhaustive but representative practices that have preoccupied philosophers of science for a number of decades. Our goal is to capitalise on the rich scholarship in philosophy of science in order to illustrate what aspects of scientific practices are important to capture in educational contexts in order to ensure the development of sound understanding of the nature of science. We draw on the research literature on video games in order to investigate the potential for understanding scientific practices through gaming. Our discussion, which is theoretical in nature, will cover classification, experimentation, observation and representation as example epistemic practices of the scientific enterprise. We will subsequently draw on some implications for science education research and practice in the context of video games, illustrating how scientific practices like classification are already embedded in video games and how future designs can best be maximised in exploiting the potential for learning scientific practices through video games. [Draft]

[26O1D-4] Exploring the Structure of Attitudes towards Science: A Study of Hong Kong Secondary Students (*A0033*)

Zhi Hong Wan

The Education University of Hong Kong, Hong Kong

ABSTRACT Although there has been extensive research investigating students' attitudes towards science in the last four decades, little has been done to probe the internal structure of attitudes towards science itself. In the present study, the Structural Equation Modeling (SEM) method was adopted to compare five hypothetical models of attitudes towards science. The participants were 305 senior secondary school students in Hong Kong. Findings reflect that (i) the data consistently supported the three-factor structure of the practice dimension of attitudes towards science; (ii) four lower-level dimensions of attitudes towards science (i.e., value of science in society, self-concept

in science, anxiety towards science, and enjoyment of science) could be further integrated; (iii) teachers' practice had a closer relationship with the practice component of students' attitudes towards science than the cognition and affect components; and (iv) compared with the relationship dimension, the pedagogy dimension of teachers' practice had a closer relationship with students' attitudes towards science.

<1E> Integrated (SSI, EE, ESD)
Chair: Jessica Shuk Ching Leung (The University of Hong Kong)

[26O1E-1] Children Learn about Environmental Problems from a Japanese View of Nature: An Example from a Nursery School with a Distinctive Natural Environment (*A0294*)

Mai Sakakura*[+] and Koichi Kasahara
Miyazaki International College and Tokyo Gakugei University, Japan

ABSTRACT [Problem and purpose] Some of the goals of science education, especially at the elementary school level in Japan, are to familiarize children with nature, fill their hearts and mind with affection for the natural world, conduct observations and experiments with their own perspective, and develop a realistic understanding of the natural phenomena. These goals not only include the natural and scientific views of nature but also incorporate the characteristic Japanese view of nature (Ogawa 1998, Fujishima 2003, Nakamura 2013). The Japanese view of nature is characterized by an integration of the subject (man) and object (nature). In addition, one of the problems in environmental education is that even when children have obtained scientific knowledge, this acquisition does not directly lead to responsible behavior with regard to environmental issues. Due to this, we decided to focus on the elements of science education that emphasize the Japanese view of nature (to become familiar with nature, fill hearts and minds with affection for the natural world). Therefore, in this study, we focus on children at the nursery school level as they are in the early stage of childhood to touch nature and we thereby aim to recapture the elements of the Japanese view of nature as a concrete appearance in these children in detail. Based on the results, a discussion, which argues that the Japanese view of nature can have positive implications for the goals of environmental education with regard to impacting children's' responsible behavior in the future, follows. [Method] In a nursery school that has a distinctive natural environment (Mogushi nursery school: Kumamoto, Japan), we conducted participant observations about the context in which children play and also interviewed the principal. Mogushi nursery school has about fifty children who are from 0 years old to 6 years old. And Mogushi nursery school is located in the rich natural environment for example where near Mogushi shirahama bathing beach, fields of radish planted by children and so on. One of the main goal of them is to cherish the natural, play turned to mud in nature. We (Sakakura and Kasahara) visited there on December 17th 2015 and observed children through the day. In addition we interviewed the principal about state of usual children. And we investigated children's experience in the nature by overlaying empirical understanding of the principal and state of the children captured by observation. [Result and Conclusions] Children attending the Mogushi nursery school playing with natural objects such as water, sand, soil, sticks, and stones. In addition, due to the school's proximity to a mountain and field, children were catching fruits from tree and rolling it down the mountain. Its appearance was exactly integrated with nature. The principal reported on how the purpose of picking up trash on the Mogushi beach was integrated into the beach visits of children. The main purpose was to go to the beach to play. By frequently playing at the beach, children could feel the effect of nature on their whole body. According to the principal, this made the child feel discomfort about artifact (for example trash) and think about the plight of other creatures. From these results, when children simply learn in the midst of nature, they do not take the necessary steps toward responsible behavior on environmental issues from the scientific knowledge gained. However, when placed in an unclean natural environment, children act (for example, picking up trash) simultaneously while feeling the effect of nature on their whole body. Thus, for children in early education that promotes learning with the Japanese view of nature both ("learning about environment" and "learning for environment") are accomplished at the same time.

[26O1E-2] Wonderful Science Education for Spring in Korea: Integrated Science Education Based on Disney movie 'Frozen' (*A0404*)

Sua Lee[1]*, Chang Won Seok[2+], Eun Shik Jung[3+], Jun ill Park[4+], Yun Jung Lee[5+], and Won Seok Choi[6+]
1. ScienArt Research Institute, Kyungpook National University*, 2. Sangin High School, 3. Daegu Science Gifted High School, 4. Gumi Girl's High School, 5. KERIS+, and 6. Sinsang Middle School, Korea

ABSTRACT This study tries to offer possibility of wonderful and systematic science education that makes students feel national pride by introducing imaginary context based on Disney movie 'Frozen(2013).' This movie achieves global popularization through fantastic science world with the theme of love between family(Kowalski & Bhalla, 2015; England et al., 2011). In other words, original characters in Disney have weak image and gradually change into active image. Particularly, 'Frozen' presents the image of modern woman who works out her own destiny(England et al., 2011). In addition, Disney creates character of various races and may pursue noble beauty that exceeds racism. The great scientists take an active part in high quality research and realization of utopian society(Song, 2016). This study developed PIA(Problems for Imaginary context that introduced Artistic factors) that was consisted with 4 problems(science, everyday life, humanities related problems, and creative design) based on this movie. Subjects of this study included 2 of grade 11 female students in Daegu, South Korea. They were participated in evaluation about PIA for 40 minutes, and were interviewed for detailed analysis. And then, this study examined logical, creative, and integrated thinking on problem solving process of PIA. The results of the study are as follows. First, in all of the given problems of PIA, students' logical thinking and elaboration were observed. Second, in problems relating to everyday life and humanities, originality and integrated thinking(science, high technology, medical science, philosophy, and so on) were observed. Everyday experience and cultural life such as reading have a possibility to bring positive effects to these thinking. Third, in problem relating to humanities, it can be seen that science education needs beautiful approach to build an

upright character since students have various perceptions of love. Lastly, students mentioned about consideration for the poor in creative design. Accordingly, science education may need to propose roles of science to achieve an ideal society.

[26O1E-3] Teaching Science Using Art Enhances Process Skills: Observe, Communicate, Compare, Measure, Organize (*A0425*)

Lovelyn Cabansag Blanco
Harris Memorial College, The Philippines

ABSTRACT The current educational system demands for high academic outcomes and loaded with heavy requirements for the students to fulfill in one school year. The tendency is for the teachers to maximize the time teaching the students with passive strategies like listening to the teacher's long discussion, reading textbooks, copying from the blackboard, and the like. This is the scenario that can be seen in a classroom almost every day, believing that these are the best ways to meet all the academic requirements in all the subject areas – Reading/Language, Math, Social Studies, and Science. Science for young children (K-2) is doing and thinking. They are very curious about everything in their world and how it works. They always wonder, explore, and question things around them. The essence of Science is discovery, and should be taught systematically and creatively. Knowledge, understanding, and outcomes are explored through hands-on or practical activities. But because of the heavy demands of the educational system, even Science is being taught in a very traditional way- focusing on learning, reading, writing, and memorizing the terms and the definitions, and that is all. This may lead to poor development of the children's process skills in Science – observe, communicate, compare, measure, and organize. In this study, Kindergarten pupils and Primary graders (K-2) of Harris Memorial College in Taytay, Rizal, Philippines were given Creative Science instruction using Art activities like collage, painting, printmaking, pasting, modeling, and drawing. Rubrics to measure the children's observations, ideas, and descriptions through the art activities are formulated for results and interpretations. Interviews with the students were made for their perceptions on science and the art activities. This study examines "Will Science and Art integration enhances the children's Science skills?" and "Which skill is more affected and enhanced by art integration?" The children's learning was evaluated from the Art perspectives as well as from the Science perspectives. Arts made them more experienced at observing similarities and differences, color, shape, size, texture, patterns, and symbols as they engaged in drawing, painting, sculpting, modeling, and pasting. I anticipated that the students would develop and enhance their Science process skills- observe, communicate, compare, measure, and organize. The results of the Rubrics made for the study showed high scores on details, thus, the process skill of observation was enhanced more. Interviews disclosed the following: observations lead to more questions, asking questions is basic and significant in doing Science. Art and Science are naturally connected. By doing Science through art, students were involved and created strong observations, and through observations, they see the details of things they study. Details imply characteristics and properties – the size, shape, color, texture, weight and volume. These details now lead the children to measure and compare one thing to another. Then they construct and organize ideas and descriptions about things around them that can be shared to others, written or spoken, and so organization and communication skills are developed. This study provides a Science-Art Integration that teachers can use for their Science classes. This will also kindle their minds to choose creative and proactive teaching than the traditional and passive one.

[26O1E-4] Informal Reasoning Regarding Socioscientific Issues among Science Majors and Non-science Majors: Using Obesity as a Context for Study (*A0309*)

Jessica Shuk Ching Leung*+
The University of Hong Kong, Hong Kong

ABSTRACT Socioscientific issues (SSI) are issues emerging from the interrelationship of science and society (Sadler, 2004) that are often factually and ethically complex, without clear-cut solution and subject to ongoing inquiry. Waiting for conclusive evidence before taking actions on these issues would hardly be an option. Scientifically literate citizens are expected to be able to make informed decisions about SSI for oneself and for the society in the midst of conflicting evidence, values and belief. The process of making decisions regarding SSI engages individuals in informal reasoning which happens when individuals attempt to work out contentious problems without clear-cut solutions (Means & Voss, 1996). Research studies comparing the informal reasoning between science majors and non-science majors have been conducted. It was reported that the social science majors were able to generate more justifications than the science majors (Christenson, Rundgren, & Zeidler, 2014), and science majors' skills of informal argumentation were significantly better than those of the non-science majors (Chang & Chiu, 2008). It was also found that science majors tended to apply more analogies whereas non-science majors tended to use more justifications based on authority (Chang & Chiu, 2008). With few participants being able to generate the complete indicators of informal argumentation, Chang and Chiu (2008) urged for more investigation on undergraduates' performance of informal argumentation. Reasoning is the core of argumentation (Means & Voss, 1996). This research aims to examine the informal reasoning regarding SSI among university students in the context of obesity, in particular, the characteristics exhibited by undergraduates in their informal reasoning regarding SSI related to obesity and the differences in those characteristics in relation to their subject background.

<1F> Teachers (Teacher Education)

Chair: Tetsuo Isozaki (Hiroshima University)

[26O1F-1] The Predictive Effects of Teacher-Level Factors on TIMSS Grade 8 Students' Science Achievement: A Comparative Study between Malaysia and Singapore (*A0001*)

Lay Yoon Fah[1]*+, Ng Khar Thoe[2], and Khoo Chwee Hoon[3]
1. Faculty of Psychology and Education, University Malaysia Sabah, 2. SEAMEO RECSAM, Penang, and 3. Teacher Education Institute Kent Campus, Tuaran, Sabah, Malaysia

ABSTRACT There is growing evidence that teacher

preparation is a powerful predictor of students' achievement, perhaps even overcoming students' socioeconomic and language background factors. In addition to the importance of a college or university degree or advanced degree, the literature reports widespread agreement that teachers should have solid mastery of the content in the subject to be taught. In a review of teacher quality research, the relationship between teachers' advanced degrees and student achievement was examined and found a positive relationship between subject-specific advanced degrees and student achievement in science. Besides, evidence from recent meta-analyses of research shows that teacher professional development focused on science content has a significant positive effect on student achievement and that the amount of professional development was an important factor. A meta-analysis of the effects of teachers' subject matter preparation on their students' achievement in science found some studies showing a positive effect, but in general results were mixed. Research have also shown that teachers' self-confidence in their teaching skills is not only associated with their professional behaviour, but also with students' performance and motivation. Hence, higher science achievement was related to teachers' having more teaching experience, being confident in their teaching, and being satisfied with their careers. The purpose of the present study is to examine the predictive effects of teacher-level factors (i.e., formal education, majoring in education and science, years of experience, professional development, preparation to teach the TIMSS science topics, confidence in teaching science, career satisfaction, collaborate in improve teaching, instruction to engage student in learning, resources teachers use for teaching science, emphasis on science investigation, computer activities during science lesson, and science classroom assessment) on science achievement among 5,733 and 5,927 eighth grade Malaysian and Singaporean students who participated in the TIMSS 2011 assessment, respectively. [Draft]

[26O1F-2] Bird's Eye View on Science: Pre-service Science Teachers' Representations of Nature of Science (*A0015*)

Ebru Kaya[1*+] and Sibel Erduran[2,3]

1. Bogazici University, Turkey, 2. National Taiwan Normal University, Taiwan, and 3. University of Limerick, Ireland

ABSTRACT The Family Resemblance Approach (FRA) is a framework on nature of science (NOS) (e.g. Erduran & Dagher, 2014; Irzik & Nola, 2014). Erduran and Dagher (2014) proposed and extended version of FRA and argued for a holistic approach to NOS. FRA-based NOS covers a range of aspects of science including aims and values, methods, practices, knowledge as well as social-institutional dimensions of science. These authors have also generated a series of images that summarise some key aspects of the various aspect of NOS. For example, they summarized a simple triangle classification of the epistemic, cognitive, and social aims and values of science. They proposed what's called a "Benzene Ring Heuristic" (BRH) inspired from the benzene ring structure to highlight the dynamic nature of the epistemic, cognitive and social components of scientific inquiry by stressing the social mediation of data, models and explanations through argumentation and certification. Erduran & Dagher (2014) brought together the different representations about NOS aspects based on theoretical rationale collectively referring to these images as "Generative Images of Science" (GIS). GIS are visual tools for communicating NOS. The images are generative since each of them has the potential to be extended and embellished. The significance of visualization in science teaching and learning has been extensively reported in science education research literature (e.g. Gilbert, Reiner, & Nakhleh, 2008). Furthermore, visualisation is important for teaching because representations are considered a key element of PCK (Van Driel et al, 1998). This paper draws on a primary pre-service science teacher education project informed by an FRA-based NOS approach and based at a university pre-service teacher education programme in Europe. The particular aim of the paper is to report on pre-service science teachers' learning of NOS representations produced as part of the project. Qualitative data were collected from 14 pre-service teachers. The data collection instrument consisted of 2 parts. In the first part, the participants were asked to draw pictures to communicate their depiction of various aspects of science such as methods and practices of science. In the second part, they were given GIS and asked to explain what they understand from each image. Results include a range images to represent NOS aspects. For example, for the aspect of social context of science, one pre-service teacher drew stick figures and money suggesting that science has a financial dimension and it is part of society. In terms of GIS, one participant considered BRH as a useful tool to summarise scientific practices holistically. Overall the study suggests that the FRA-based NOS framework used in the study contributed to pre-service teachers' representations of NOS. Given the conventional approaches to NOS (e.g. Lederman et al., 2002) have not relied on the use of visual imagery to depict NOS, the present study contributes to studies on NOS by providing a visual dimension. Since the current study also focus on primary pre-service science teachers' representations of science and scientific practices, the findings contribute to the research about science teachers' PCK specifically teachers' representations of NOS.

[26O1F-3] A Qualitative Study on Effectiveness of Educative Mentoring during Teaching Practice in Schools (*A0073*)

Takuya Ochi*+ and Tetsuo Isozaki

Hiroshima University, Japan

ABSTRACT The collegiality is one of the primary factors of teacher knowledge development (e.g., Wellington & Ireson, 2008; Akita, 1993). In the case of teaching practice, especially, involvement with the mentor would play an important role in student teachers' outcomes of teaching practice. Recently, educative mentoring have been regarded as that mentors engage in teaching practice collaboratively with their student teachers, although traditionally, mentoring had been regarded as that mentors instruct what/how to teach itself without its reasons (Barnett & Friedrichsen, 2015; Bradbury, 2010). However, the effectiveness of educative mentoring and how educative mentoring contributes to student teachers' learning during teaching practice have not been discussed adequately. Therefore, this study focused on the following two research questions: how effective is educative mentoring during teaching practice in schools?; how do effective mentoring contribute to student teachers' learning during teaching

practice? To answers these RQs, we conducted the interview survey that was participated in two mentors (conveniently they were named mentor A and mentor B) and nine student teachers. All of the student teachers was students of National University C, and have done teaching practice at both Secondary School D Attached to National University C and Secondary School E Attached to National University C from September to November, 2015. And also, Mentor A belongs to Secondary School D and have guided all of them, and Mentor B belongs to Secondary School E and have guided two of them. Then, we conducted a roughly thirty-minute semi-structured interview with the mentors and student teachers. The student teachers were asked to talk about what they had learned through teaching practice and their challenges. The mentors were interviewed about their view of science lessons and teaching practice, and what was devisal point for teaching practice. Then, the data was analyzed qualitatively utilizing SCAT (Otani, 2008, 2011). As a result, we could point out the followings: educative mentoring could allow student teachers to begin to consider what science lesson is; they reflected on their classroom practice during teaching practice based on their view of science lessons that they had begun to recognize influenced by their mentors; being guided under a couple of mentors could enable student teachers to learn multiple views of science lessons and attitude as a teaching profession. Consequently, educative mentoring prompts student teachers to construct their view of science lessons, and contributes to allowing them to conduct teaching practice reflectively. This would clarify that student teachers' learning during teaching practice should be regarded as an initial stage of continuing professional development.

<1G> Teaching/Learning (Learners)
Chair: Mijung Kim (University of Alberta)

[26O1G-1] A Study of Inquiry-Based Instruction Integrated with Information Literacy to Improve Students' Learning of the Concept of Mini Ecosystem (*A0021*)

Jia-Hong Lin[1]*+, Jia-Ying Lin[2], and Shu Ching Yang[1]
1. National Sun Yat-sen University, Taiwan, and 2. National Taiwan Normal University, Taiwan

ABSTRACT In an information society, information literacy is as essential as basic reading and writing. Information literacy can be viewed as the ability to effectively locate, retrieve, organize, and evaluate needed information then there is much in common with the principles of scientific literacy and the skills needed to be a scientifically literate person. The purpose of this study is to investigate the effects of two factors: the integration of information literacy and the level of academic achievement in a mini ecosystem inquiry around a 5E (engagement, exploration, explanation, elaboration, and evaluation) instructional model. 102 7th grade students from four classes of a junior high school participated in this study. A quasi-experimental design was used, in which the experimental group received eight weeks of information literacy -integrated 5E instruction (a real-time internet information searching task integrated) and the control group received non-information literacy -integrated 5E instruction (traditional teaching with oral explanation) for the same content and for the same period of time. Pre-test, post-test and assignment task of biology achievement were administered before and at two different time intervals after the instruction. The result shows that the experimental groups' students performed better on both post-test and assignment task scores than control group students. And the ANCOVA results indicate that when the pretest score is considered as a covariate, the difference in the level of academic achievement of assignment task is statistically significant. In summary, this study suggests that integration of literacy information in 5E instruction has the potential to enhance the student's learning, especially task-solving ability.

[26O1G-2] Children's Reasoning as Social Action (*A0024*)

Mijung Kim*+
University of Alberta, Canada

ABSTRACT Research shows that children's reasoning emerges in and through the complex relationships of knowledge, theories, and evidence in their decision-making and problem solving. Yet, most of the research on children's reasoning skills has looked into individualized and controlled research settings, not collective classroom environments where children often engage in learning and reasoning together to solve classroom problems. The current study takes children's reasoning as collective social action in regular science classrooms and examines how the process of collectivity emerges from classroom interactions and dialogue between children as they attempt to solve their classroom problems. The study investigated children's classroom actions and reasoning process in science classrooms in a local school in Western Canada. 8 second graders, 8 third graders and a teacher in a multi-grade class participated in the study. Twenty science classes were video recorded and analyzed through interactive video analysis method. The study findings suggest that children's reasoning involves active evaluation of theories and evidence through collective problem solving and developed consensus through dialogical reasoning. The implication of collective problem solving and teacher scaffolding as reasoning process will be further discussed.

[26O1G-3] Comparing Cognitive and Affective Effects between Drill & Practice and Role-playing Models in Playing Fire Games (*A0319*)

Jon-Chao Hong and Ming-Chun Tsai*+
National Taiwan Normal University, Taiwan

ABSTRACT This study focused on the game effects of using different learning approaches: Drill & Practice and Role-playing approaches. Role-play means students play certain roles acts to solve problems in any situation, and Drill & Practice means promoting the acquisition of knowledge or skill by repetitive practice. We chose 2 groups based on random assignment: one group used drill & practice approach from a website developed by city government; the other group used role-playing which developed by National Taiwan Normal University. This study aimed to explore the difference in perceived ease of use and usefulness, cognitive load, and gameplay interest. By adopting an experimental design and four classes for 10 minutes trial, this study invited totaling 101 seventh grade students participated. After the experiment, the students filled in a questionnaire for our data collection and analysis. The results showed that: (1) On the difference in perceived ease of operation

indicated Drill & Practice was easier than Role Playing; (2) On the difference in perceived usefulness between this two game, the result revealed that Drill & Practice model less than Role Playing model; (3) On the difference in cognitive load after students learned, indicated students had lower level of Drill & Practice than Role Playing; (4)) On the difference in gameplay interest, the result showed that students has lower level of Drill & Practice than Role Playing; (5) On the difference in learning achievement, the result showed there was no significant difference between Drill & Practice and Role Playing in a trial. The implication suggested, if the experiment for students to take more trials, those cognitive and affective learning effect may have different results.

<1H> ICT

Chair: Jiwon Lee (Korea National University of Education)

[26O1H-1] Mobilised Learning – How Investigative Approach and Mobile Technologies Empowers the Learners for Deeper Learning – Two Case Studies in Singapore (*A0326*)

Nai Shun Nelson Chong

Technologies for Learning Branch/Educational Technology Division, Ministry of Education Singapore, Singapore

ABSTRACT This paper presents two case studies for the design and use of mobile technologies in enhancing investigative learning in two separate contexts - a Primary Science context and a Secondary Mathematics context. The pedagogical principles discussed in the paper can be applied to designing lessons to flow from the classroom to outside the classroom, allowing students to apply their knowledge and skills in a physical real-world authentic context for engaged and deep learning. Lave and Wenger (1991) argue that learning is situated within authentic activities and context. They highlighted that learning is more likely to take place when the learners can put what they learned to use immediately in authentic situations. Literature reviews have highlighted how technology, in the form of mobile devices, have served as mediating tools, allowing students to capitalise on the situation and encouraging communication and archiving (Shih, Chuang, & Hwang, 2010; Tan & So, 2011). In this innovative curriculum, the lessons are designed to connect what the students have learned in Science (Primary School), Mathematics with Computer Applications (CPA) knowledge (Secondary School) and situating them in a real world context, supported by the use of mobile technologies. The paper highlights how the two schools redesigned their existing curriculum infused with mobile technologies, providing a platform to develop important 21st century competencies and skills: self-directed learning, collaborative learning and effective communication. In the Primary School context, the Primary Four Science students used mobile tablets (iPads) installed with Light sensor app, spreadsheet app and presentation app to help them collect real world data, summarise, present findings and make informed decisions. In the context of the Secondary School, the Secondary One students used mobile tablets (iPads) installed with Google Forms to collect data (responses) from tourists to help them make evidenced-based decisions to improve their brochures on places of interest. The paper also explores the critical success factors and challenges experienced by the schools in its implementation. The effectiveness of the use of mobile technologies was evaluated based on feedback from teacher observation during lessons, feedback from discussions between the teachers and Ministry of Education (Singapore) officers, students' surveys and engagement towards learning and the quality of the digital artefacts created. Our findings suggested that leveraging mobile technologies, use of investigative approach and use of real-world contexts not only promoted 21st century competencies but also enhanced learning outcomes for the learning of Primary Science and Secondary Mathematics. The self-reported survey conducted from the Primary Four Science students showed significant appreciation for science lessons that included the meaningful use of technologies for inquiry. Teachers' reflections from both schools showed that as lesson designers, teachers can re-design their lessons to deepen students' learning through real-world application supported with technologies. The use of mobile technologies provided students with opportunities to collect and analyze data, construct explanations, and evaluate ideas. The paper provides insights on how the two schools' rich experiences could be applied into meaningful classroom practices.

[26O1H-2] Collaborative Knowledge Construction using an Online Annotation System (*A0466*)

Jiwon Lee* and Eric Mazur[+]

Korea National University of Education, Korea and Harvard University, USA

ABSTRACT We studied the collaborative construction of knowledge facilitated by an online annotation system in a flipped class. Students used the online system to collaboratively annotate the pre-class reading assignments by asking questions, responding to questions, or placing comments. The annotation threads reveal the students' knowledge structures. For example, asking questions (or answering them) exposes lack of knowledge or misconceptions that persist after the pre-class reading. At the same time, even just reading annotation threads without contributing to them can help spread knowledge. In this study we examined the 638 annotations in 286 threads made by 64 undergraduates in one chapter of a physics textbook. We developed a taxonomy of annotation types that permits us to reliably classify the individual annotations in each thread. We next looked for relationships between the annotations and the students' prior knowledge and self-efficacy. Finally, we examine the amount of knowledge sharing in each thread. In our presentation we will show the interaction between students in an online annotation system can lead to collaborative knowledge construction.

[26O1H-3] Study on Roles of Smart Devices on Model-based Learning in Elementary Geo-science Class (*A0198*)

Eunjin Jang*, Chan-Jong Kim, and Seung-Urn Choe[+]

Seoul National University, Korea

ABSTRACT Model-based learning in science class is for students to construct scientific models, which represent an object, event, process, or system by focusing on key features to explain and scientific phenomena. In model-based learning, students need scaffolds from teachers and peer students when they generate and modify their models.

However, they cannot provide enough aid since those agents have limits. To improve this situation, we adopted smart devices in modeling and tried to find what roles the smart device can play. To reveal the roles of smart devices, this study was conducted in two elementary classes of 5th graders, which is consisted of 29 boys and 31 girls, in a metropolitan city in Korea. The classes were designed for students to make their own model of solar system in a small group using a smart device, and they took place twice for a block of two hours in a week. The result is as follows; First, students could generate models of higher understanding level models when many students could share information provided by smart devices. Also, smart devices can provide both various types of information and feedbacks from diverse agents, which can be helpful for students to generate, estimate and modify their models. Except for that, smart devices offer not only enrichment material but also various and convenient tools for presenting their models. However, there still have difficulties for adopting the smart devices in model-based learning. To improve the situation, it is necessary to bring about an improvement in poor infrastructure for network and inconvenient applications.

[26O1H-4] Employing Flipped Classrooms: An Instruction Embedded with Multiple-mode Representations to Teach Elimination Reaction Mechanism (*A0248*)

Sheila Shamuganathan[1]*, Mageswary Karpudewan[2], and Sumathi Ganasen[3]

1. Penang Matriculation College, 2. University Sains Malaysia, and 3. Surya College, Penang, Malaysia

ABSTRACT Various instructional strategies were employed to teach organic chemistry at the undergraduate level. The challengers of effectively teaching this course comes from large amount of content that need to be served in a shorter period. To cut short students were asked to memorize the content of organic chemistry without understanding the concepts behind each reaction. Flipped classroom in an approach that employs asynchronous video lectures, reading assignments practice problems, and other digital, technology based resources outside the classroom, and interactive, grouped based, problem solving activities in the classroom. In the context when the curriculum content is overcrowded, Flipped classroom serves as an alternative. As such the purpose of the study is measure the effect of flipped classroom embedded with various mode of representational in understanding elimination reaction mechanism in alcohol in a matriculation college. The average age of these students are 18 years of age pursuing high school level education. Matriculation college caters for the top performing students throughout the country. A quasi experimental design was used in this study involving 71 students from two intact classes which have were randomly classified as experimental (N=71) and control (N=71) groups. The usage of multiple modes of representation was measured quantitatively using five open-ended questions periodically. Understanding of the elimination mechanism of alcohol were identified by the average score of the five questions using one way analysis of co-variance (ANCOVA).The outcome of the result demonstrated that students post-test scores are significantly different (F1,139)= 16.84,p<.00) after controlling the pre-test scores. The results suggested that using flipped classroom enhances the uses of multiple-modes of representation and improves the understanding of elimination mechanism in dehydration of alcohol. This study implies that chemistry educators could encourage students to use multiple-modes in addressing the difficulties in learning difficult concepts in organic chemistry. Flipped classroom would be one of the feasible way.

<1I> Curriculum/Assessment/Policy

Chair: Bing Wei (University of Macau)

[26O1I-1] School Science Teaching and Learning in Macau: Problems and Challenges (*A0118*)

Bing Wei

Faculty of Education, University of Macau, Macau

ABSTRACT Based on the data of the evaluation project of science education in primary and secondary schools in Macau, this paper attempted to analyze the following issues concerning science teaching and learning in this region - School-based science curriculum, science textbooks and their uses, science teaching methods, science learning environments, and students' attitudes to science and school science by use of classroom observations, questionnaires, interviews. The data were collected from six comprehensive schools (primary and secondary), which were typical in terms of numbers of students, teaching quality and social reputation in this special administrative region of P. R. China. The features of school science teaching and learning in Macau are characterized as follows. Firstly, there were great discrepancies among the various schools, with each school having a unique feature. Secondly, science teachers had a certain degree of autonomous power in planning daily science teaching. Thirdly, the teaching of the science curriculum and the use of science textbooks were to a great degree influenced by Mainland China. Fourthly, routine science teaching was heavily reliant on textbooks. Fifthly, science lessons were dominated by science teachers and lecturing was the most prevalent teaching method. Sixthly, neither the regular classroom environment nor the laboratory environment was fully consistent with the constructivist tenets in the views of students. Seventhly, students had positive attitudes to science, and had interest in school science, but few students opted to choose science as their college majors owing to the worries of few job opportunities in science or related industries in Macau. In the last part of this paper, these features are discussed on whether they are conducible to the purpose of achieving scientific literacy.

[26O1I-2] A Study on the Conceptual Understanding of "Rainfall Phenomena and Related Conceptions" on Fourth-grade Students and their Teachers (*A0162*)

Gaixiao Zhou[1]*, Cheng Liu[2], and Enshan Liu[3+]

Beijing Normal University, China Mainland

ABSTRACT The important goal of science education is to improve students' scientific literacy, while the understanding of scientific concepts is a key component of scientific literacy. The study aims to investigate the cognition of the rainfall phenomenon and its related concepts, as well as misconceptions existing in the fourth grade primary school students and their teachers. We use the Rainfall Concept Test for teachers and students as our

survey tools and collected data from 58,572 fourth-grade students of the same area and 383 fourth-grade teachers. The teachers and students belong to the same school. The study analyzes the teachers', their students' misconceptions and the cognition of the rainfall phenomenon, the correlation between their test scores, and the consistency and differences between their conceptual understandings. The main results of the study are detailed in the following points:(1) In the correlation analysis, there is a significant positive correlation between the teachers' and their students' scores;(2) Both teacher and student have misconceptions of the rainfall phenomenon;(3) Consistency exists in the understanding between teachers and their students, they can both use "evaporate" to explain the rainfall phenomenon, but are easy to overlook or fail to realize the role of "gravity" in the process of rainfall phenomenon; and (4) In terms of difference, although teachers can use "the condensation of water" to explain the rainfall, students cannot use it very well. The study indicates that teachers' understanding on content knowledge could be a factor to influence the students' conceptual understanding to a certain extent. Teachers need to pay more attention to their own understanding of content knowledge as well as students' misconceptions in classroom teaching in order to help students achieve a deep understanding of scientific concepts.

[26O1I-3] A Study on Method of Trend Researches using R (*A0551*)

Seokhyun Ga*, Eunjin Jang, Chanjong Kim, and Seungurn Choe+

Department of Earth Science Education, Seoul National University, Korea

ABSTRACT Current researches adopt basic statistical tools to analyze research trends. On account of the tools' limitations, human researchers have to collect data by reading all the articles. Consequently, this methodology can limit the amount of data, and the researchers could not analyze massive materials. In order to overcome this limitation, this research aims to develop a useful methodology using R, which is well-known programming language in other industries. The best feature of methodology in this study is that computer program carries out the whole process to analyze huge amount of data. This program not only collects the data about journals, but also constructs the keyword database of them. After that, it determines inter keyword relationships. To help people understand these relations, it represents them in network map. Also, this map is designed with three-dimensional CG in order to improve readability of the map. Since all the process is done by computers, there could be a chance to have a problem like inaccuracy. However, modifying and elaborating the program by conducting pilot test can take care of this problem.

[26O1I-4] A Comparative Study of Science Teachers' Beliefs on Lessons between Japan and England (*A0300*)

Susumu Nozoe* and Tetsuo Isozaki

University of Miyazaki, and Hiroshima University, Japan

ABSTRACT Learning contents of science are delivered to students through the control process at different levels. For instance, it is inevitable that 'Implemented Curriculum' defined by IEA have gaps between 'Intended Curriculum' and 'Attained Curriculum'. Because there are certain cultures of schools, teacher's beliefs and other factors that affect science lessons actually. According to some literatures, for example, Ryder, J., & Banner, I. (2013) analyzed the effect to secondary science teachers by reforming National Curriculum, and Hanley, P., Ratcliffe, M., & Osborne, J. (2007) also examined science teachers' experiences of teaching 'ideas-about-science' in Twenty First Century Science. On the other hand, in Japan, there are a few researches relating to science curriculum policy. Generally, Course of Study and National Curriculum affect science teachers in the classroom practice (e.g. Bosch, M., & Gascón, J., 2006). Therefore, science teachers also affect science curriculum because they have own beliefs of science lessons. The objective is to assess the factor in forming (lower secondary) science teachers' beliefs on lessons. To achieve this aim, we conducted a survey toward science teachers in Japan and England, and also examined science teachers' perspective, the way of designing lessons and teaching science. First of all, we made the questionnaire, and conducted a pilot survey toward science teacher training course students at Hiroshima University (Japan) and University of Leeds (England). After modifying the questionnaire on the basis of pilot survey results, we completed the questionnaire. Next we conducted a final survey toward 84 science teachers at lower secondary schools in Hiroshima and 24 science teachers at comprehensive schools in Leeds. Number of valid responses was 79 people and 24 people respectively. The data from the questionnaires were summarized in tabular form and statistical tests applied as appropriate. We performed cross-tabulations between science teachers' beliefs on lessons (e.g. science teachers' perspective, the way of designing lessons and teaching science) and personal attribute (e.g. gender, teaching experience, specialist teaching subject), respectively. Results by Fisher's exact test indicated that significant differences were not recognized in all combinations ($p>.05$, n.s.). Therefore, we could interpret that science teachers' beliefs on lessons don't depend on personal attribute in each country. Next, we performed cross-tabulations with regard to science teachers' beliefs between Japan and England. Results by Fisher's exact test indicated that significant differences appeared in all items, though differ in degree (science teachers' perspective: $p<.05$, the way of designing lessons: $p<.001$, the way of teaching science: $p<.01$). Therefore, we could interpret that science teachers' beliefs on lessons depend on the difference of country. We can conclude that the factor in forming (lower secondary) science teachers' beliefs on lessons depends on not personal attribute but the cultural context of each country. In other words, science teachers' beliefs on lesson are characterized by teacher's culture in own country.

<1J> Informal Settings

Chair: Nelson C. C Chen (National Kaohsiung Normal University)

[26O1J-1] An Empirical Edutainment to Enhance the Motivation of Science Learning: A Case Study of Multi-functional Bamboo Gun at Science Bazaar (*A0606*)

Nelson Chen[1,2], Chia-Ju Liu[2], and Young-Shin Park[3]

1. National Science and Technology Museum, 2. Graduate School of

Science Education, National Kaohsiung Normal University, Taiwan and 3. Department of Earth Science Education, Chosun University, Korea

ABSTRACT Many studies have pointed out that a competitive game, e.g. video game, can significantly enlighten the motivation of science learning. The paper aims to raise an empirical case of how the science learners or participants were devoted to spend more time in creating more ideas and exploring the variables that affect the function of progression of bamboo gun by a competitive game at the science fair run by the science museum for publics. An edutainment games related to the multi-functional bamboo gun were designed by science museum for the publics to play at the science bazaar. People can explore variables of how to enhance the multi-functional bamboo gun and science-related games to be more attractive and interesting. A quasi-experiment research was applied at an event of science bazaar from 2015 to 2016 and 52 samples were surveyed at an event of science fair held by local government for students aged between 10-13. A science booth called "Intercept in the mid air" was presented for the people to play. Those who can shoot the floating ball or flying object down with the least time would be shown as the record keeper in a panel board at site. Whoever broken the record would be asked written a survey sheet, such as how many times and for what purpose it attended the same booth, what kind of the variables it used to break the record. The result showed: 1. The average times the record breaker attended the same booth was 4.5, while most of the participant attended a same booth once only at the non-competitive science booth. 2. Being proud of the record breaking that was always updated in the bulletin board at site. 3. Feeling interesting to re-try again and again as it can do more better when attending the same booth again. 4. Would try to take the challenge of good performance no matter whoever kept the record. 5. Raise suggestions to the host how to modify the bamboo gun to be more powerful and useful. 6. Pull the different position of trigger would use different force, it is related to the application of lever. 7. Aim at the front or upper side of the flying object would easily have it shot down.

[26O1J-2] Role Playing of Science News Production: An Innovative Approach of Science Teaching to Develop Information Searching, Oral and Visual Presentation Skills in Taiwanese Junior High School (*A0600*)

Hsiang-Hu Liu* and Chun-Yen Chang+

Graduate Institute of Science Education, National Taiwan Normal University and Science Education Center, National Taiwan Normal University, Taiwan

ABSTRACT "Searching for scientific stories" and "the sources and evidences of the stories" are two crucial elements when the journalists developing pieces of science news. For effective dissemination, the journalists must search efficiently for most useful information when they are trying to discover news stories in science. In addition, while presenting the news story, not only the scientific portion is condensed and transformed using a more popular language, but the story is also communicated using a clear oral skill. This study aims to observe an innovative teaching method role-playing the aforementioned science news production in real science classroom. To illustrate, students will role-play the reporter (i.e., to search for science stories and resources), main-broadcaster (i.e., to condense and transform information for the public using popular language and clear oral skills), and the stage director (i.e., to design the storyboards and visuals for presenting the stories), to simulate the authentic situation and procedure to produce science news, with the scientific stories upon the students' choices. The current study will mainly utilize qualitative research methodology of action research to better understand and observe the participant's perspective paths of changes, and their specific interactions with the instructor and their peers during an 8-weeks instruction. In addition, an AEIOU survey (i.e., an instrument that measures participants' perspectives upon experiencing a piece of science communication). The participated pupils are consisted of 38 eighth-graders and 36 seventh-graders from a junior high school in northern Taiwan. The participants are divided into eight groups to perform a series of tasks required to complete the final scientific news stories report in the last class. Result of a preliminary interview before the class showed that the participated pupils could not express their thinking sufficiently and clearly because oral reporting skills were absent. The instruction is still on the process. Detailed results will be reported and discussed upon the current research is completed.

[26O1J-3] Study on Young Children's Scientific Experiences in Urban and Rural Areas (*A0205*)

Shinsho Tamayama[1]*, Manabu Sumida[2], and Heiwa Muko[2+]

1. Graduate School of Education, Ehime University and 2. Faculty of Education, Ehime University, Japan

ABSTRACT Young children worldwide in the twenty-first century have been reported to be highly competent in science and it is imperative to reconstruct science education for this high competency. In contrast, there is an education gap between children in urban and rural areas. In urban areas, young children have a variety of opportunities to study science but not enough time and environment to experience nature. Children in rural areas live in a rich environment (e.g., sea, mountain) but their access to science education is limited. This study compares scientific experiences of children in rural and urban areas. A questionnaire survey was conducted for 492 children in elementary school grade 1 and 2 in the urban and rural areas of Ehime Prefecture. The questionnaire consists of mainly four parts; 1) Scientific experiences in nature and their surroundings, 2) Experiences about science and technology, 3) Scientific experiences at home, 4) Knowledge of science. The result showed that children in rural areas had more experiences in nature and their surroundings than those in urban areas, but had less scientific experience (e.g., observing natural phenomena, using public education facilities, owning a science book). And more children in rural areas were interested in an informal science education programme than those in urban areas. Rural areas were found to have a rich environment but children in those areas did not try scientific investigation in their surroundings.

[26O1J-4] Teaching Biology in the Context of Cultural Presentation: A Case Study (*A0019*)

Fernan P. Tupas
School of Arts and Sciences, Northern Iloilo Polytechnic State College, The Philippines

ABSTRACT This qualitative research focused on informal science that emphasis on dance and culture to communicate biology. The methods used in finding biology ideas, concepts and practices were interview, conversational and document analysis, observation and photo elicitation. The results were utilized to developed instructional materials using cultural presentation in teaching biology to all grade levels in Junior High School K to 12 Basic Education Program . The informants were group into the steering committee, production staff and performers, such as warriors, star dancers, prop men and drummers. The tagline or commonly called theme of Dinagyang Festival were religious and marketing strategies in anture. However, it was evident in 2004, 2005, 2006, 2008, 2009 and 2012 that biological concepts and ideas were inserted in the themes. Biology ideas and concepts in the criteria and rules and regulations were the use of indigenous and recycled materials for the costumes and props, human safety and consideration for the performers, the senses for creating the production designs, costumes and props to have visual impact, life energy and kinesiology for the movements, as well as the organ specifically the brain because of the clarity of ideas and mastery of the dance figures of the competing tribe. Biology ideas, concepts, practices, and principles were found in the performance of the competing tribe in terms of costumes, props, storyline, music and sound, and sustenance in the celebration of Dinagyang Festival. Biology ideas and concepts found were muscle, bones and joints, facial expression, and long term memory. Also, biomolecules and nutrients, the used of indigenous and recycled materials, and Genetics. Dance routine of the competing tribe joining in Ati competition of Dinagyang Festival is a synchronized action of several muscles with the help of bones and joints. In terms of speed, strength, endurance, agility and energy biology ideas and concepts were also evident. The speed and agility used different organs, like the legs, hands, and brain for the fast pace choreography, metabolisms which is one of the function of endocrine that fuels the energy needed, and also oxygen were required for breathing. While in the strength, muscles and bones were found embedded because of the power to moves big props and to cope with the dynamic changes of movements, directions and as well as the costumes. Endurance is always refers to cardiovascular. This will boost stamina to sustain the type of performance in the Dinagyang Festival. And, energy was always related to the nutrients and minerals given to the warriors. They have to eat properly, drink enough water, sleep well and vitamins for muscle toning. [Draft]

<1K> Curriculum/Assessment/Policy
Chair: Chia-Yu Wang (National Chiao Tung University)

[26O1K-1] Tracer Study of BSMT and BSMarE Graduates of the College of Maritime Education of the University of Perpetual Help System DALTA (*A0067*)

Angelo Magdangal A. Maderal, Liwanag Elizares, and Marino Mugot
University of Perpetual Help System DALTA, The Philippines

ABSTRACT Education is an integral part of individual professional growth. Tracing individual growth after graduation is one of the institution's responsibility. To be able to meet the requirement of the industry and its clients, the graduate tracer study becomes a significant tool in helping the university achieve its goal in producing competent and well equipped graduates. It provides a basis for evaluation and strengthening of the current programs of the College of Maritime Education. The study attempted to determine the appropriateness of the curriculum and the ship-board student training program to the various works situations of the graduates by analyzing their job tasks and how they relate to the curriculum of the University. The study made use of survey research method using the forms the alumni filled-up at the Alumni Office where a representative sample is drawn from the population. Descriptive measures were utilized in the treatment of data gathered from the study including frequency counts, mean and percentage. The results revealed that majority of the respondent graduates are employed in a work environment they were educated and trained and that the primary reason for taking the course BS Marine Engineering and BS Marine Transportation is to earn higher income.

[26O1K-2] Better Way to Elicit Thinking Process? Comparing Concurrent and Cued Retrospective Reporting Techniques (*A0136*)

Chia-Yu Wang*+, Ke-Wei Lee, and Chih-Shen Hsu
Institute of Education, National Chiao Tung University, Taiwan

ABSTRACT Educators are eager to grasp techniques for eliciting individuals' thinking processes to diagnose novices' obstacles or uncover experts' decision-making process in order to design instructions or scaffolds to facilitate science learning. An appropriate eliciting technique needs to uncover both cognitive (e.g., actions taken for execution) and metacognitive (e.g., monitoring and evaluating) processes. This study aims to compare the two most widely used eliciting techniques, concurrent (CON, e.g., thinking-aloud) and cued retrospective reporting (Cued-RE) techniques, regarding their abilities to elicit cognitive and metacognitive process, since which technique provides a more comprehensive picture of thinking process was not examined. Evaluating scientific explanations was framed as the task context since it is one of the important scientific literacy (OECD, 2013). These types of complex tasks were ill-structured and often involve different phases of information-processing. The task consists of four phases of information processing including: (1) reading and understanding the research question and conditions of a science experiment, (2) analyzing a set of second-hand data, and then (3 and 4) making judgments on quality of two given scientific explanations based on the given information in (1) and (2). Each section was displayed in sequence, and the participants processed one section at a time in order to examine the effects of tasks features and length on the two techniques. 40 undergraduate participants were recruited and were randomly assigned into either the CON or Cued-RE group after receiving a training section on both reporting techniques. No difference was found between the two groups on their level of knowledge on biology and on scientific explanation. Participants in the CON condition

reported aloud whatever comes to their mind during the entire task-solving process; whereas the Cued-RE group solved the task silently while their eye-movements were recorded and replayed later as a stimulus for process reporting after task completion. Participants' cognitive (reading and comprehending, data analyzing, inferring and integrating) and metacognitive (monitoring, evaluating) process were analyzed for comparisons. The results showed that the effectiveness on eliciting metacognitive process was equally competitive (reading context: t=-1.87, p>.05; analyzing data: t=0.28, p>.05); however, the effects on eliciting cognitive process vary depending on task features. Concurrent reporting is more powerful for uncovering information processing when making sense with textual information (t=-4.22, p<.001), whereas cued retrospective reporting is beneficial for revealing processes involving nonlinear, abstract reasoning (t=2.45, p<.05). Although both techniques were compatible on revealing cognitive (judgment 1: t=1.14, p>.05; judgment 2: t=-1.69, p>.05) and metacognitive process (judgment 1: t=1.06, p>.05; judgment 2: t=-1.68, p>.05) during explanation evaluation, the ability for uncovering cognitive process decreased significantly when the task was longer due to memory lost (t=3.32, p<.01). Other constrains for the cued retrospective reporting technique include more fabricating and reconstruction of thoughts. Findings of this study suggested that science educators should choose an eliciting technique wisely with a consideration of task features and be aware of the effect of memory lost on a longer task when using cued retrospective reporting technique. Literature review, discussions and implications will be reported in the full paper.

[26O1K-4] Biology Investigations in Senior Secondary Classes of Hong Kong (*A0139*)

Kwok-chi Lau
The Chinese University of Hong Kong, Hong Kong

ABSTRACT This is a study to investigate how the implementation of the new senior secondary curriculum of Hong Kong in 2009 impacts the practical work of biology. In the new curriculum, biology practical work is assessed through the School Based Assessment (SBA). This study analyzed over 1000 SBA biology investigations from over 400 schools and compare them with that of the past A-level curriculum and other regions. A lab task analysis framework was developed based on the frameworks developed by Fisher and Hofstein (1998), Chinn and Malhotra (2001) and Germann et al (1996) to delineate the authenticity, openness, cognitive structures, complexity, etc. of the investigations. Preliminary findings revealed that very limited number of full investigations were done in the three years of senior secondary and most of them were relatively simple. The underlying reasons for the changes were explored through interviewing the teachers and document analyses. The most common reason was that dealing with the new public exam left them with little time to do practical work. More complex issues were discussed in relation to the whole curriculum reform in Hong Kong, which will shed light on issues of curriculum changes and implementation in other regions.

<1L> Curriculum/Teaching Materials

Chair: Shih-Hui Hsiao (National Taipei University of Education)

[26O1L-1] Development of 3P(Play-Plan-Puzzle) Teaching Module to Improve Learning Achievements and Argumentation Ability of Medium-low Achievement Fifth Graders Studying in Plant Unit of Nature Study (*A0120*)

Shih-Hui Hsiao*[+], Hui-Lun Huang, and Yu-Yen Chiang
Department of Science Education, National Taipei University of Education, Taiwan

ABSTRACT We hope to effectively improve learning achievements and argumentation ability of medium-low achievement students through the understanding of teaching strategy "learning while playing". Therefore, 44 students (two classes) are randomly selected from the fifth grade of schools A and B of Keelung as the experimental group and 28 students (one class) are randomly selects as the control group to execute the teaching research. Based on the teaching strategy "learning while playing", the nature and life technology of the fifth graders in first semester were developed in this study, i.e. a card aid of the plant world, and the teaching module "Play-Plan-Puzzle" was used to teach students of the experimental group. Students of the control group were taught through the traditional oral teaching method. Before and after teaching, learning sheets and examination paper are issued to evaluate pre-post test, and the method "paired t-test" is used to analyze learning outcomes and argumentation ability. After the teaching experiment, the pre-post learning outcome of learning achievements and argumentation ability of medium-low achievement students of the experimental group have significant difference (P< 0.01 and P<0.05, respectively), however, there are no significant difference (P> 0.05) of high and medium-low achievement students of the control group. Furthermore, it was helpful to the high achievement students of the experimental group (P< 0.01) in learning outcomes and wasn't to improve the argumentation ability (P> 0.05). This shows the teaching module has a practical and significant help for improving the learning outcomes and argumentation ability of the medium-low achievement students.

[26O1L-2] A Comparative Study of Matter in Chinese Physics Curriculum Standards and NGSS: Based on Learning Progression (*A0260*)

Yi Yang*, Yu-ying Guo[+], and Jian-xin Yao[+]
Department of Physics, Beijing Normal University, China Mainland

ABSTRACT Learning progression, which offers a promising framework to help students build a coherent understanding of science, has received much attention in science education: Core ideas and their related learning progressions are key organizing principles for the design of science learning (NRC, 2012). The concept of matter is highlighted as one of the disciplinary core ideas or/and crosscutting concepts, as understanding the concept of matter is vital important for students to understand the complex science knowledge and to link the different domains of science (e.g. Guo, 2014; MOE China, 2011; NGSS Leading States, 2013). However, the curriculum design on this important topic lacks a cross-cultural examination. Therefore, with the lens of learning progression, this study focuses on the concept of matter in secondary school, and compares Chinese physics curriculum standards of

secondary school and the Next Generation Science Standards (NGSS). The purpose of this study is to find out the similarities and differences of matter between above documents. To achieve this purpose, we first construct a two-dimension learning progression framework of matter based on research on the learning progression of matter (Hedenfeldt, 2014) and the complexity model from the perspective of cognition (Commons, et al., 1998). In this framework, we group the concept of matter into 3 categories: a) physical properties, b) physical change, c) structure and composition, and use 5 levels: 1) facts, 2) mapping, 3) relation, 4) concept, 5) integration to describe students' understanding. Based on this framework, we subsequently compare and analysis Chinese physics curriculum standards of secondary school and the Next Generation Science Standards. Through comparison, we find the following results: (1) Both the NGSS and Chinese standards exhibit a clear progression of matter concept, which follows a pattern similar to the 5 understanding levels in our framework and is consistent with existing learning progression of matter as well (e.g. Liu, 2005; Hedenfeldt et al., 2016). (2) There are some differences between NGSS and Chinese standards in some categories and in certain understanding levels (e.g. China's standards propose higher expectation on the micro-view understanding). (3) The NGSS emphasizes the integration by explicitly fusing practices (e.g. scientific modeling, scientific explanation), crosscutting ideas (e.g. energy) and the understanding of matter itself, while China's standards are trying to reach the integration through deepening the understanding and using the concept in complex context. The framework developed in this research indicates that the research on learning progression can offer a systematic perspective for international curriculum comparison. This study ends with a briefly discussion on further implications for following-up empirical study and revision of Chinese physics curriculum standards.

[26O1L-3] The Use of "Pokemon" to Enhance Learning of Taxonomy in Biology (*A0419*)

Tao-Jen Yang* and Meichun Lydia Wen+

Graduate Institute of Science Education, National Changhua University of Education, and National Hemei Experimental School, Taiwan

ABSTRACT Scientific classification is commonly adopted to investigate the biological diversity after billions of years of evolution. However, senior high school biology textbooks in Taiwan lack the activities to judge the classification when teaching the taxonomy concept. Students tend to use higher-order classification units (such as mammals, insects, mollusks, etc.) when they learn taxonomy, which usually leads to the failure to judge the most basic features of biological classification. In order to improve such difficulty in teaching taxonomy, our teaching practice aimed to instruct students to make dichotomous flowcharts use "Pokemon" figures as an example. The 18 types of Pokémon figures resemble the higher-order taxonomy units, while the detailed features such as various kinds of body color, hair, ears, and so on resemble the basic features of classification in biology. In our study, we invited 108 11th-grade students to participate our teaching practice. During classroom discussion among students, they realized that those 18 types of Pokémon such as "electric type" and "water type" were not suitable for classification, but the features such as body color were the foundations for classification. After the Pokémon activity, they were then asked to classify 56 species available in their textbooks. Students' learning progress was observed and they later took a two-tier diagnostic assessment with 14 items. The result showed that students learned to classify different species based on the "characteristics" of the figures. Students were able to discuss with each other while they collectively modified their dichotomous flowcharts of the 56 species, based on their previous experiences classifying Pokémon. Their assessment scores also improved after instruction. We also compared the differences between science-oriented and social science-oriented students and found that this teaching was more efficient for the science-oriented group. The discussion and implications of the study will be provided.

[26O1L-4] Developing, Implementing and Promoting Argumentation Training for High School Curriculum in Taiwan (*A0585*)

Yi-Pei Tang[1+], Yi-Wen Hung[2], and Ying-Shao Hsu[1]

1. Graduate Institute of Science Education, National Taiwan Normal University and 2. The Affiliated Senior High School of National Taiwan Normal University, Taiwan

ABSTRACT Argumentation is an important trend in science education worldwide that is also a key competence helping students to face the changing world in the future. There are many studies suggesting that argumentation can help students foster a higher level of thinking and expression capability in communication. This research aims to develop an argumentation-training curriculum for high schools in Taiwan and investigate the effectiveness of implementation and promotion. The course adopts Toulmin Argumentation Pattern (TAP) as an argumentation framework of this curriculum. The case school is one national senior high school in Taiwan Taipei City and objects of trial demonstration in the curriculum consists of 10th graders over a three-year curriculum development. Implementation of the curriculum adopts inquiry-Based teaching to conduct argumentation instruction. This curriculum features as follows: the course uses local daily agendas in life and provides various instructional scaffolding and three-phased curriculum modularization. 1."Argumentation in Daily Life" : By moving in the everyday life argument form of dialogue, understanding the purpose of demonstration occurred type of dialogue, argument and then import the presentation elements. 2."Preliminary Argument" : Import science topics argumentation and reasoning using a simplified TAP mode (less "rebuttal") to help students to further explore the relationship between logic and its application proof structure. 3. "TAP argumentative model" : Complete discussion of argumentation model that allows students to understand the integrity of the reasoning process. In this study, through self-designed argumentation ability test, classroom observation, teaching reflection, analysis of the course learners learn. The effectiveness of the implementation of the curriculum shows that this curriculum effectively improves the argumentation capability and argumentation quality of students while strengthens students' comprehension of knowledge structure and improves the critical thinking capacity. In addition, to make the curriculum better handle four screenings teacher corps. Through the feedbacks from

teachers for the curriculum promotion conducted by national teachers' workshop reveal that this curriculum not only helps to teach with substantial benefits, but also helps teachers reflect on the process of knowledge structuring. Results of the study will also be incorporated into the Taiwan 2018 General Senior High School compulsory subjects as the example in the "Exploration and Practice" for Fundamental Earth Science Curriculum Outline.

Oral 2 (26th, 15:00-16:00)

<2A> Learners (Teaching/Learning)
Chair: Yu-Ta Chien (National Taiwan Normal University)

[26O2A-1] Development of an Instrument to Examine Engagement and Participation in Classroom: Science (EPIC-S) (*A0441*)

Wanjoo Ahn[1]*, Hye-Eun Chu[2], Sonya Martin[1+], Yu-Ta Chien[3], Chun-Hui Jen[3], and Chun-Yen Chang[3]

1. Seoul National University, Korea, 2. Macquarie University, Australia, and 3. National Taiwan Normal University, Taiwan

ABSTRACT In this presentation we describe the refinement an instrument we previously developed and validated called the Engagement and Participation in Classroom (EPIC) survey targeting middle and high school students. In an effort to include a greater focus on student participation and engagement practices in science classrooms, for this research, we described how we refined the questionnaire to have include a focus on student perceptions about participation and engagement in science classrooms. In this talk, we describe new features and items on the Engagement and Participation in Classroom - Science (EPIC-S). While the EPIC survey originally included 31 questions (divided into six sections) with one-five Likert Scale (strongly agree, agree, neutral, disagree, strongly disagree), the EPIC-S includes 65 questions (divided into nine sections) with a one-four Likert Scale (strongly agree, agree, disagree, strongly disagree). The EPIC questionnaire included questions about general demographic information (ex. gender, age, grade level) (5 items) and students' preferences and perceptions about seating patterns in class (5 items). We expanded this section to collect 12 additional items on the EPIC-S focused on student preferences and experiences engaging in private after-school "cram schools". The EPIC survey included sections to measure students' preferences and perceptions about the general learning environment (4 items); the use of different science teaching strategies (8 items); students' perceptions about how to effectively participate in science class (11 items); students' perceptions about what teachers value in a science learner (4 items); and students' perceptions of themselves as a learner (4 items). The EPIC-S includes a section to measure students' perceptions about (8); their attitudes and beliefs towards science (4); and their beliefs and attitudes about participation in cram schools (6). In addition to these three sections, we added a total of 16 new items to the six previously described sections. Following a brief discussion comparing the two questionnaires, we then share some initial findings from data collected from students in science classrooms in Taiwan and Korea. Using students' positive answer percentage and ANOVA analysis, we conducted a simple analysis to investigate factors, such as students' science achievement and gender, on their perceptions of engagement and participation in their science classroom. We share similarities and differences in student responses in each country we discuss some factors that could contribute to these findings. Specifically we focus attention on the potential for students' participation in after-school private education institutions as an important factor shaping students engagement with school science during the regular school day. We conclude our presentation by raising some questions about the ways in which cultural differences in Korea and Taiwan may influence students' science classroom practices. Building from this discussion, we offer implications for science teaching and learning in each context. We conclude by sharing our future research plans for exploring similarities and differences in student participation and engagement patterns in each context.

[26O2A-2] Comparison of Science Classroom Environment and Culturally Sensitive Factors of Science Learning between Thailand and Korea (*A0443*)

Jina Chang[1]*, Chatree Faikhamta[2], Jiyeon Na[3], and Jinwoong Song[4+]

1. Seong-il Elementary School, Korea, 2. Kasetsart University, Thailand, 3. Chuncheon National University of Education, Korea, and 4. Seoul National University, Korea

ABSTRACT The thoughts of community members not only reflect the community culture, but also have the possibility to reproduce the community culture. In this regard, we premised that an analysis of students' thoughts about their science classrooms could be one of the alternative ways to reveal the features of classroom culture. As the first step to figure out science classroom culture in Asia, this study compares Korean and Thai students' thoughts about their science classrooms. Specifically, in order to investigate the students' perceptions on their science classrooms in two countries, we used two questionnaires, the What Is Happening In this Class (WIHIC) and the Cultural Learning Environment Questionnaire (CLEQ). These questionnaires were administered to 1,575 students of elementary, middle, and high schools in both countries. The survey results showed various similarities as well as differences between two countries. First, in both countries, students considered giving the right answer important and tended to follow the others' thoughts in science classrooms. This feature could be interpreted by 'collectivism' in Asian culture. In collectivist culture, saving one's face is considered important. The collectivist traits in Asian culture could be reflected and have an influence on interaction in science classrooms. Second, in both countries, students tended to avoid challenging their teachers' authorities. This feature could be ingrained in 'respect for elders,' one of essential virtues in Korean and Thai societies. This virtue could have an influence on students' responses to their teachers' authorities. The interesting thing is, in Korean results, the higher school level Korean students belong to, the less students respect their teachers' authorities. Third, it was reported that Thai boys and girls were treated differently in their science classrooms while Korean boys and girls perceived that they were treated equally in their science classrooms. Based on these results, educational implications are discussed in terms of culturally appropriate pedagogies in science classrooms. We conclude with a discussion about future research.

[26O2A-3] Toward an Understanding of Students' Verbal and Non-verbal Participatory Practices in the Science Classroom (*A0442*)

Yu-Ta Chien[1]*, Chun-Hui Jen[1]*, Sonya Martin[2], Hye-Eun Chu[3], Wanjoo Ahn[2], and Chun-Yen Chang[1]*+

1. National Taiwan Normal University, Taiwan, 2. Seoul National University, Korea, and 3. Macquarie University, Australia

ABSTRACT According to a 2013 survey sponsored by the Ministry of Science and Technology in Taiwan, 88% of the surveyed students are not willing to ask, or respond to, questions during the class. The given classroom behavior is a great challenge for science teachers to face the reform demand called by the Ministry of Education in Taiwan, which emphasizes on student-centered learning; how can teachers adapt classroom science teaching based on students' ideas if students are not willing to express their thoughts during the class? This study thus aims to understand when and why students choose to perform verbal or non-verbal participatory practices in the science classroom. To achieve such a goal, a new version of the Engagement and Participation in Classroom Science (EPIC-S) survey has been developed collaboratively by scholors in Taiwan and Korea. As a pilot test, EPIC-S will be administrated to 150 students in the same high school in Taiwan. The main scales of the EPIC-S include the ambience of science classes, preference of teaching-learning methods, experience of classroom participation, purpose of science class, attitudes towards science learning, definitions of a "good" student from the teacher's perspective and student's perspective, peer relationship, student-teacher relationship, perceived value of verbal interaction, and beliefs and attitudes towards participating in cram schools. In conjunction with the results of the EPIC-S, regular school science lessons will be video-taped to identify when and how students perform verbal and non-verbal participatory bahaviours. Students who frequently perform verbal participation will be interviewed to explicate the reasons underlying their practices. So will be the students who frequently perform non-verbal participation. The interpretation of and triangulation between the aforementioned three data sources will help us to develop a more cohesive understanding of students' verbal and non-verbal participatory practices in the science classroom. Implications for improving student-centered learning in Taiwan will be discussed based on our findings. Since all students are from the same school, they may share a similar learning culture. We will bear in mind that the single case site limits the generalizability of our results.

<2B> Teacher Education (Teaching/Learning)

Chair: Siriphan- Satthaphon (Kasetsart University)

[26O2B-1] The Promotion of Preservice Science Teachers' PCK for Teaching Inquiry through Video Reflection (*A0159*)

Siriphan Satthaphon[1]*+, Pattamaporn Pimthong[2], and Teerasak Verapaspong[3]

1. Graduate Course of Science Education, Faculty of Education, Kasetsart University, 2. Department of Education, Faculty of Education, Kasetsart University, and 3. Department of Physics, Faculty of Science, Kasetsart University, Thailand

ABSTRACT My classroom action research aimed to study the effectiveness of video reflection on preservice science teachers' Pedagogical Content Knowledge for teaching inquiry (PCK for inquiry). The 37 preservice science teachers were enrolled in a Science Methods Course. Every preservice science teacher need to bring fifty minutes video about their teaching in school to class. Our activities related to reflection and discussion on preservice science teachers' video about theoretical and methodological theory into practice. Lesson plans, reflective journal writing and teachers' log were collected as data on which the following assertions were based. Data were analyzed using inductive approach. The finding showed that preservice science teachers understand more about PCK for inquiry such as encourage students lead to questioning; Encourages students to design a self-examination. However, they still lack awareness about of their students' learning and do not concern of the five features of inquiry which are learners are engaged by scientifically oriented question, give priority to evidence, formulate explanations from evidence to address scientifically oriented question, evaluate their explanations in light of alternative explanations and communicate their proposed explanations. They refocused and deepened awareness of designed to teach the nature of inquiry and students' learning. The video reflection improved their conception of PCK for inquiry and their ability to identify the five features of inquiry and problem situation with various views.

[26O2B-2] Inquiry-based Teaching for Scaffolding Thai Students' Practice of PISA Scientific Competencies: Lesson Learned from Preservice Teachers' Action Research Projects (*A0183*)

Jeerawan Ketsing*+, Chatree Faikhamta, and Akarat Tanak

Division of Science Education, Department of Education, Kasetsart University, Bangkok, Thailand

ABSTRACT Over the past decade, the Programme for International Student Assessment (PISA) has been highlighting a series of scientific competencies in which 15-year-olds students should have when completed a compulsory education in their nations. The PISA scientific competencies represent students' ability to identify scientific issues in given phenomena, explain phenomena scientifically, and use scientific evidence to support claims. Findings from this international test have become the world's premier database for policy makers and educators in making decision about education policies. In a Thai context, students have gradually improved their scientific competencies as shown in the test score from 2003 to 2012. Nevertheless, Thai students' average PISA score has long been significantly lower than the average score, and far behind the high-performing countries/economies. This piece of evidence provokes science educators in the nation to rethink about how we prepare future teachers to cope with this challenge. Therefore, this ongoing research study aims to help a group of preservice science teachers to overcome this obstacle. In doing so, five preservice teachers in our teacher preparation program at a University in Bangkok volunteered to engage in this study. Grounded in a Buddhist philosophy of Ithibath 4 (basis of accomplishment 4), the participants engaged in a teacher professional development (PD) program focusing on action research. The action research was used as a tool for nurturing reflective practitioners who are able to identify tacit knowledge that enrich students' scientific competencies. The PD program was conducted in a second semester of a

year-long school internship, from October 2015 to January 2016. Data were collected from interview transcriptions with the participants, classroom observations, and the preservice teachers' action research reports. Data are analyzed using inductive analysis. Tentative findings show that teaching techniques in inquiry-based pedagogy that promote PISA scientific competencies are: 1) a use of role play where students take a role and duty of a scientist in given problem situations; 2) a utilization of true laboratory experiment and hands-on activity where students manually collect data by themselves and point out which data set used for supporting their claims; and 3) a creation of classroom culture where students value scientific inquiry process as equal as its products. In addition, the preservice teachers reported that key factors in the PD program that support their learning include: caring university mentor, formal meeting with peers and university advisor, and learning by actually doing it in their classrooms. The study seeks for further discussions and sharing from science education community about effective strategies and/or systems for preparing future science teachers.

[26O2B-3] Analyzing the Relationship between Teacher's Questions, Time, and Student Responses (*A0509*)

Sungho Kim
Bukyeseo Elementary School, Korea

ABSTRACT This study examined the differences and patterns for three categories between an argument-based inquiry group and a traditional group over the period of the SWH (Science Writing Heuristic) project: (1) teacher talk time, (2) structure of questions (question types), and (3) student responses. The participating teachers were chosen randomly by a convenient sampling method because the data were collected and the groups were divided into two groups previously from the SWH project. Each group had thirty teachers. A total of sixty teachers participated in the study. Student responses were part of the study to evaluate the effect of open-ended question types but students were not direct participants in the study. Each teacher was asked to send a recorded video clip of their class at the end of each semester (spring and fall) over two years. Each teacher sent four video clips for the project. A total of two hundred forty video clips were analyzed to gather the information regarding the three categories. The first category was teacher talk time. It was measured in seconds only when teachers interacted with students with the topic. The second category was the structure of questions (question types). It consisted of two question types (open-ended and close-ended). Under the open-ended question category, there were three sub-question types: (1) asking for explanation (AE), (2) asking for self-evaluation of reasoning (AF), and (3) asking for self-evaluation of others' reasoning (AFO). Under the close-ended question category, there were two sub-question types: (1) asking for factual information (AI) and (2) asking for confirmation (AC). Each sub-question type was counted numerically. The last category was student responses. Student responses consisted of higher-order thinking and lower-order thinking. Under the higher-order thinking category, there were three sub-types: (1) explanation responses (E), (2) self-evaluation of reasoning responses (SE), and (3) self-evaluation of others' reasoning responses (SEO). Under the lower-order thinking category, there was one sub-type: simple responses (S). Each sub type was counted numerically. Based on the descriptive results (the length of teacher talk time in seconds, the number of question types, and the number of student responses), repeated measures ANOVA was conducted to find any differences and patterns for teacher talk time, structure of questions and student responses between the treatment and control groups over the period of the project and across time (four different time points). The results showed that there were clear differences for teacher talk time, the structure of questions, and student responses between the treatment and control groups over the period of the project and at each time point. The treatment group teachers talked less and used more open-ended questions than the control group teachers. The treatment group students displayed more higher-order thinking responses than the control group students.

<2C> Integrated (SSI, EE, ESD)
Chair: Ah-Nam Lay (The National University of Malaysia)

[26O2C-1] The Attempt of Identification Experience with Nature to Develop Attitudes of Loving Nature in Japanese High School Biology: Based on the Practice of Deep Ecology Work (*A0297*)

Yoko Yamamoto
Faculty of Human Sciences, University of Tsukuba, Japan

ABSTRACT Environmental education aiming at fostering attitudes of loving nature by harmony and fusion with nature is a one of the major characteristics of Japanese environmental education. The idea of harmony and fusion with nature is included in the core idea of deep ecology, which is one of the American representative environmental ethics. Nowadays, in the West, it has been a matter of great importance to change their conscious of making personal life-style more ecological in order to bring the sustainable society into reality. One of the influential environmental educations aiming to change their conscious is the environmental education embedded deep ecology. The concept of the deep ecology has evolved with development of ecology. There are only two cases relating to introducing the idea of deep ecology into a field of ecology learning at high schools. One is Biological Sciences Curriculum Study (BSCS), which is the most famous biology curriculum in the US. Another is a practical study of the author in Japan. However, in BSCS, it does not include a deep ecology core idea of "self-realization by identification with nature", therefor there are no learning activity to acquire the idea. How do students' awarenesses change by experiencing "the self-realization by identification with nature"? The purpose of this study is to identify a characteristic of changes in their awarenesses toward environmental ethics among Japanese public high school students by the experience. The author has developed and conducted an environmental ethics educational program based on the core idea of deep ecology in the field of ecology in "basic biology"(so called Seibutsu-kiso in Japanese). The program, "experiences of identification with familiar nature in the school yard" was conducted by the author. Questionnaire survey was performed by 122 students in the first grade. The result of the survey, in particular focusing on the free description space, was analyzed. As a result of this research, the following characteristics of changes in students' awarenesses toward environmental ethics among students,

were cleared. Their awarenesses of loving nature have grown by several reasons. Two of the major reasons were: 1) The students felt a comfortableness through interacting with nature. 2) The students have experienced identification with nature. In the conclusion, this program, "experiences of identification with familiar nature in the school yard" embedded in "basic biology", raised the students' awarenesses of the love to nature.

[26O2C-2] Enhancing Korean Middle School Students' Key Competencies through Collective Intelligence based SSI Instruction (*A0458*)

Yunhee Choi[1]*, Hyunju Lee[2], and Yeonjoo Ko[2]

1. Soong moon Middle School and 2. Ewha Womans University, Korea

ABSTRACT Our assumption of the study is that SSI instruction is an effective tool to promote key competencies that students must master as future citizens living in a scientifically and technologically developed society. And to increase the effect of context of SSIs, the Principles of Collective Intelligence facilitates their learning. Thus, we designed and implemented SSI lesson plans over 15 weeks every Saturday for about 2-3 hours and observed the effects of the program on enhancing students' communication, collaboration, critical thinking, and information management skills. Twenty 9th grade students voluntarily participated in the extra-science program. We designed SSI lesson plans on six topics, such as Nano-science, Designer baby, euthanasia, Food Additives, Space Development, and Nuclear Power. Data was collected by administering a questionnaire to examine the skills before, in the middle of, and after the instruction, and by conducting classroom observations and focus student group interviews. The results indicated some degree of improvement in their targeted key competencies. First, they experienced the expansion of their thoughts by actively sharing information and ideas using the web platform. Second, they became more flexible and open to different points of views in order to accomplish a common goal. Third, they appreciated having independent time and space to explore their own positions on the issues and to search necessary information, and believed that the process encouraged them to more pro-actively participate and communicate in the group debates. Lastly, they positively perceived the values that collaboration with diverse group members could produce. [Draft]

[26O2C-3] The Effect of MyKimDG Module on Students' Achievement and Motivation in Chemistry (*A0349*)

Lay Ah-Nam* and Kamisah Osman

The National University of Malaysia, Malaysia

ABSTRACT Chemistry is perceived as a difficult and unpopular subject due to the abstract nature of chemical concepts. The Salt topic in Malaysian Chemistry Curriculum is considered the toughest topic. Studies revealed that the problem which causes difficulty in the Salt chapter is that students are lacking of understanding of the chemical reactions involved. Previous studies have found that digital game-based learning (DGBL) is an effective approach to enhance students' academic achievement and motivation in learning. Based on this approach, Malaysian Kimia Digital Game (MyKimDG) module has been developed. In MyKimDG, we applied one possible approach to DGBL, which allow students to take on the role of game designers, developing digital games that related to the chemical reactions involved in the topic. A quasi-experimental study was carried out to investigate the effect of MyKimDG on students' achievement in the Salt topic and motivation in chemistry. A total of 138 Form Four students from four secondary schools in Malaysia participated in the study. Two schools were randomly chosen to use the MyKimDG module and the other two served as control group. Results of t-test showed that there was a statistical significant difference in achievement in the Salt topic for the treatment (M = 37.15, SD = 12.70) and the control groups (M = 19.29, SD = 10.99); $t(129) = -8.50$, $p < 0.001$. A doubly-multivariate analysis of variance was performed to investigate the group differences in motivation in chemistry at two time points (pre and post interventions). Six dependent variables were used: self-efficacy, active learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation. Results revealed that the interaction between group and time is statistical significant for self-efficacy [$F(1, 136) = 10.96$, $p = 0.001$; partial eta squared = 0.075]. Descriptive statistic showed that students' self-efficacy improved significantly between pre-test and post-test for treatment group. Our results suggest that MyKimDG can help improve students' achievement in the Salt topic and their self-efficacy.

<2E>STEM

Chair: Kenichiro Mori (Hokkaido University of Education)

[26O2E-1] The "Technology" Element in the Primary Science Education in China and Suggestions of "Design and Technology" Courses in Primary Schools (*A0156*)

Qi Kang*[+] and Bangping Ding

Beijing Institute of Education and College of Education, Capital Normal University, Beijing, China Mainland

ABSTRACT The STEM approach has been widely used in science education all over the world either in the developed or developing countries. This approach has also been introduced to China in recently years. As a country that has begun to carry out its primary science curriculum just for the recent decades, is it possible to carry out the STEM integrated science courses in Chinese primary schools? What's the current situation of primary science education in China? What is the influence of the global STEM education on China? The purpose of this study was to investigate the situation of the STEM education being carried out in China, especially with regards the "technology" element in the Chinese primary science education. Based on the science education "design and technology" course in some western countries and the current educational policies and national science curriculum standards in China, it is suggested that "design and technology" course should be an compulsory part in China's primary school science curriculum, trying to provide some references and directions for the coming reform of the national primary science curriculum standards in China. [Draft]

[26O2E-2] STEM Habits of Mind: Its Meaning and Components (*A0052*)

Anongnat Karunram*, Pinit Khumwong[+], and Teerawat Prakobphon[+]

Srinakharinwirot University, Bangkok, Thailand

ABSTRACT The purpose of this study is to clarify the definition and to identify the element of STEM habits of mind. The process of this study is included 2 steps. First, literature about scientific, technological, engineering, and mathematical habits of mind and relevant literature were analyzed and compared to synthesize the definition and elements of STEM habits of mind. Second, the proposed definition and elements were evaluated by five experts using questionnaires. Then the definition and elements of STEM habits of mind were adjusted. The findings are follow: STEM habits of mind is the way of thinking that focuses on the integration of science, technology, engineering and mathematics to solve problems in the real world. The STEM Habits of Mind are composed of 6 features; 1) Curiosity is the characteristic of a person to find new knowledge about science, technology, engineering and mathematics that are shown by asking questions on their own interests, carrying out the research and starving for knowledge. 2) Carefully Making decision is the characteristic of a person to consider, plan, and gather evidences about science, technology, engineering and mathematics and testify the reliability of the information carefully before making a decision. 3) Integrative thinking is the ability to analyze, classify the elements related to the issue or problem. Then create a solution by making connection among those elements using knowledge of science, technology, engineering and mathematics. 4) Recognizing cause and effect is the characteristic of a person to accept the ideas or explanations supported by evidences from reliable sources of science, technology, engineering, and mathematics; without adding their own opinions. 5) Communicative ability is the ability to present, explain, and discuss ideas to other people effectively and appropriately by using knowledge of science, technology, engineering and mathematics. 6) Innovative ability is the ability to apply the knowledge of scientific, technology, engineering and mathematics to invent new variety of things or new procedures. In this study the indicator of each element are developed and describe.

[26O2E-3] Proposal of the Concept of Implementing STEM Education in Japanese Middle Schools (*A0368*)

Kenichiro Mori[1]*+, Akihide Kayano[2], Dan Takahashi[3], and Satoshi Fujikawa[1]

1. Hokkaido University of Education, 2. Simane University, and 3. Nusamai Lower Secondary School, Japan

ABSTRACT Together with the learning contents for each grade, the curriculum for science education in Japan is structured according to the following four scientific concepts: “energy,” “particles,” “life,” and “earth.” The concepts of energy and particles are used for structuring studies of physics and chemistry. The concept of energy is much more abstract; fewer exercises have therefore been developed for energy. In Japan, whether or not to associate these four concepts with the teaching of science is currently up to the individual discretion of educators. Although the term energy is widely used in vernacular speech, the concept of energy is highly abstract, and hence there is a disparity in the understanding of the concept among children. In elementary schools, for instance, the term energy often appears in association with the study of food and nutrition in domestic science classes; however, as a rule, it is not used in science classes. A curriculum that intentionally emphasizes the concept of energy was developed by referencing contents from the STEM Education and put into practice in classrooms. The STEM Education comprises "Seven Crosscutting Concepts." One of the "Seven Crosscutting Concepts" is "Energy." The lesson unit dealing with the practical implementation of this curriculum was called "Chemical Changes Relating to Atoms and Molecules," taught to second-year (eighth grade) students. This lesson unit under the current Japanese curriculum deals with “Heat” associated with “Chemical Changes,” but it does not focus on the relationship between "Energy" and "Heat," at the second-year level. The relationship between Energy and Heat was dealt with in exothermic reactions. The National Energy Education Development (NEED) Project is based on the National Science Education Standards in the United States, which is known as a representative example of energy education projects. Relevant teaching texts translated by Nagasu and his associates (2005) are available in Japan, which can be used for teaching at elementary and junior high schools. An attempt was made to elicit student understanding of the subject by using a part of such texts to explain the association of heat with oxidation and the chemical combination of iron by using the concept of energy. The plan for the class lesson was formulated with the aim of making students associate "chemical reaction" with "energy" through this practical implementation. An evaluation of this practical implementation in the class was performed using the Image Mapping Test (IMT), which confirmed the effectiveness of the method. The IMT is a tool that is used to write terms associated with a particular keyword, which is written at the center of a concentric circle, in concentric rings around the keyword. This method was used to evaluate whether students were able to associate the term "Energy" with the keyword "Chemical Change." The IMT implemented prior to the class revealed that no student associated "Energy" with "Chemical Change." However, the IMT implemented after the class showed a significant number of students who associated "Energy" with "Chemical Change."

<2F> Historical/Philosophical/Sociological/Cultural/Gender Issues

Chair: Sibel Erduran (National Taiwan Normal University/ University of Limerick)

[26O2F-1] Infusing Epistemic Practices in Chemistry Curricula: A Theoretical Framework (*A0014*)

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1. National Taiwan Normal University, 2. University of Limerick, Ireland, and 3. Bogazici University, Turkey

ABSTRACT The importance of the history and philosophy of science (HPS) in science education in general, and in chemistry teacher education in particular, has been extensively acknowledged by policy makers, educational researchers and teacher educators (AAAS 1989; Matthews 1994; NRC 1996; McComas, 1998). Accordingly, a number of rationales and practical proposals have been issued in the last two decades with the aim of incorporating HPS in the science curriculum (Duschl, 1990; Matthews, 1991, 2000). Chemistry has maintained quite a peripheral existence in the philosophy of science thus evading focused

attention and critical analysis (Erduran, 2013). It is not surprising, then, the chemistry curricula have rarely been examined from an epistemic perspective although some studies have been carried out on textbooks (Kaya & Erduran, 2013; Niaz, 2008). However since the 1990s an increasing number of books, journals, conferences, and associations focused on philosophy of chemistry highlighting the contributions of chemistry to philosophy of science (van Brakel, 2000) with significant implications for curriculum design. The uptake of this new domain in the context of chemical education research and practice has been minimal despite some earlier acknowledgment of the potential significance of this field for chemical education (Erduran & Mugaloglu, 2014; Scerri, 2007). The purpose of this paper is to develop a theoretical framework on how the epistemic practices of chemistry can be integrated into the chemistry curriculum. Theoretical perspectives on philosophy of chemistry will provide the literature background on the epistemic practices of chemistry such as modeling and argumentation in the context of organic chemistry. Example curricula and syllabi from around the world will be examined to explore the curricular context. Curriculum analysis will be guided by a theoretical tool developed by Erduran & Dagher (2014) called "Benzene Ring Heuristic" (BRH) which incorporates the epistemic, cognitive and social-institutional dimensions of the nature of science in the conceptualisation of scientific practices. The BRH includes key epistemic categories such as data, models, explanations and predictions. The BRH is extended as a methodological tool for curriculum analysis. The paper will illustrate international curriculum examples to show what epistemic practices of chemistry are included. For instance, reference will be made to the Next Generation Science Standards in the USA and the Secondary Chemistry Curriculum in Turkey. The BRH further helps investigate those aspects of epistemic practices of chemistry in the chemistry curricula that are either missing or underdeveloped. For example although various epistemic practices such as the role of data, experiments and observations in chemical inquiry are highlighted, how these features collectively contribute to modeling or predictions are underrepresented in the curriculum. Suggestions for curriculum revision are discussed to enhance the use of epistemic practices in chemistry education. Overall, the paper illustrates how BRH can be effectively used to inform curriculum analysis and revision. Ideas developed in the paper contribute to the broader literature on history and philosophy of chemistry and its use for the improvement of chemical education.

[26O2F-2] A Historical Case Study on Educating 'a love of nature (shizen)' in Rika (School science) in Lower Grades in Elementary Schools in Japan: Focusing on the Elementary School Attached to Hiroshima Higher Normal School (*A0083*)

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Hiroshima University, Japan

ABSTRACT In Japan, there has been no Rika (School science) as an independent subject for the 1st and 2nd grades since 1989. Rika is taught from the 3rd to 6th grades in elementary schools. Rika in the lower (from the 1st to 3rd) grades in elementary schools remains one of the big problems on Rika in Japan (Nogami, 2005). Some previous studies suggested historical significance of the 'teigakunen Rika tokusetsu undo' (e.g., Itakura, 1968). This 'teigakunen Rika tokusetsu undo' means the movement to establish a subject of Rika in the lower grades from the 1900s to 1940s. Some elementary school teachers and professors in (higher) normal schools greatly and hotly debated the objectives and contents of Rika in the lower grades in the movement. Teachers emphasized educating 'a love of nature (shizen)' in the minds of children as one of the objectives of Rika in the Elementary School Attached to Hiroshima Higher Normal School (HHNS) which had engaged in the movement. Isozaki (2014) pointed out that the objective of Rika in elementary schools has been characterized as being in the affective domain a love of nature which is based on the Japanese view of nature which has differed from the West since the establishment of Rika. Ogawa (2013) said that it is in the study of living organisms that 'loving shizen' in Rika is most visible, and adduced these examples. However there are no historical studies focusing on elementary school teacher's ideas and practices of educating a love of nature in Rika in the lower grades. We aimed to analyze the ideas and practices of educating a love of nature in Rika in the lower grades in HHNS. In this study, we analyzed books and research papers written by teachers in HHNS in the early Showa era (1926-1989). As a result, we found that teachers in HHNS strongly emphasized educating a love of nature as one of the objectives of Rika in the lower grades, for the reasons that Japanese born in nature and grow up in nature, Japanese have ethnic character which love nature, and a love of nature arouse a feeling of curiosity about nature. Teachers also emphasized to make pupils contact with nature herself, and be familiar with nature as one of the teaching policies. Teachers put these ideas into practice in HHNS. The case study on educating a love of nature in Rika in the lower grades in HHNS may give some hints for rethinking the characteristics of Rika in Japan.

[26O2F-3] Explicit-reflective Teaching Chinese Junior High School Students' Conception of NOS (*A0244*)

Xiao Huang
Zhejiang Normal University, China Mainland

ABSTRACT The present study explores ways to enhance junior high school students' understanding of the nature of science (NOS), which is the prominent aspect of scientific literacy and is put forward in Chinese revised science (including the physics, chemistry and biology) curriculum standards. Given that the nature of science is a cognitive outcome, the explicit-reflective instructional approach based on the history of science have been proposed and stressed. "What is the junior high school students' conception of NOS? Does students' NOS understanding improve with regard to explicit and reflective teaching instruction on different aspects of NOS based on history of science?" the overarching research questions of the present study were put forward. A total of four phases were implemented in the present study. The first phase determined the status of middle high school students' understanding of NOS. The survey served as an overall investigation of students from schools in districts with different economic levels and attempted to answer the first research question. Pre-test, teaching intervention and post-test are comprised to answer the second research question. The pre-test tried to test students' understanding

of the science, such as subject to change, creative, bade on observation and inference, socially and culturally embedded. The post-test after the treatments provided detailed information about students' understanding of NOS and attempted to answer the second research question through the explicit-reflective NOS teaching by using history of science. The participants (n=736) who completed the survey were junior high school students who resided in different cities in Zhejiang province, where is the only province implemented the integrated science curriculum. One experiment and one control class of 23th junior middle school of Wenzhou were chosen to participate the pre-test, treatment and post-test. As to the treatment, some aspect of NOS were taught explicit by using history of science. Several scientific topics, such as air pressure, Auxin discovery, Newton fist law, temperature measurement were chosen to be taught with explicitly present aspects of NOS, students were further to be provided a series of questions of NOS reflection. According to the survey, students' conception of "empirically based", "creativity" is somewhat good, it attributed to the Chinese educational culture which stresses the role of experiment and observation for science and scientific research, regarding science as truth, and emphasizes the influence of technology on science and scientific research. However, it is difficult for them to understand other aspects of NOS. Overall, the students show the blur understanding of the "subject to change", "necessarily subjective". There are bias understanding "socially and culturally embedded", the difference of the scientific theory and scientific laws is especially the most difficult for them to understand. The explicit-reflective connection between history of science and NOS aspects helped middle high school students develop more sophisticated views about what science is, how science is done. The improvement was observed in students' understanding on "creative" and "empirically based", which students can understand according to the survey. And the significant improvement was made in other aspects of NOS, which are tentativeness, observation and inference, subjective, and social and cultural embedded. It is the most difficult for students to foster the conception of "laws and theories", which needs further instruction.

<2G> Curriculum/Assessment/Policy (STEM)
Chair: Rei Kato (Tokyo University of Science)

[26O2G-1] Study for the Basis of Designing Biology Education in Undergraduate Education from Students' Learning Experiences in Senior High Schools (*A0076*)

Rei Kato*+ and Kazuo Kitahara
Graduate School of Mathematics and Science Education, Tokyo University of Science, Japan

ABSTRACT Life science or biology in 21 century has changed into an interdisciplinary research area. Besides biology major, general understanding of biology is required of students of non-biology majors, as well. Biology education research for biology majors has been researched by university teachers (most of them are scientists of biology): for instance curriculum studies, materials development for students' experiments and cognitive research of students' learning process. On the other hand, biology education research and practice for non-biology majors has less discussed. Some report of science education (or STEM education) for undergraduates mentioned that teachers in charge should concern students' various learning experience, what they learned in senior high school including alternative conceptions and what they already know about the discipline. In Japan, referring to research of biology education for non-biology major undergraduates, most of them are studies of pre-service science teachers training: how university teachers in department of education train their students who are almost majoring the humanities. But situation of biology education for students who are majoring natural science and engineering not biology (e.g. physics, chemistry or mathematics) remained unclear. We already surveyed student textbooks of various subjects used in high school in our country and suggested that undergraduates have studied science of biology and biology-related issues not only in school biology but also in other subjects (reported in EASE2015). To reveal the situation of biology education for non-biology major students, we have analyzed syllabi of biology lectures held in our university (one of the upper level university of science and engineering in Japan) as a case study of Japanese college science education. The university has 5 science and engineering-related department and provides Introductory Biology-like lectures for non-biology major students as liberal arts subjects. We found 2 types of structure: wide but superficial or narrow but deep. In the first type, those lectures have various biological topics from molecular to ecological level. Comparing to Campbell Biology text, which is one of the famous biology textbook used at undergraduate level, this type placed emphasis on comprehensive understanding biology. In the other type, they focused on specific topics: most of them focused on genetics and cellular biology. In both curriculums, however, although it was a little limited interpretation, we couldn't find the concern for student' prior experience in those syllabi. Thus it has suggested that university teachers who develop curriculum of biology lectures need to make connection between what students have been expected to learn in their senior high school days and what they are going to learn in their college life for improving biology teaching and learning.

[26O2G-2] 3D printed Small Animal's Water Server as Experimental Tools of Atmospheric Pressure (*A0158*)

Katsunori Kanahara* and Yasufumi Kawamura+
Tokyo University of Science, Japan

ABSTRACT The water pressure and the atmospheric pressure are the domains to learn at the junior high school first grade as a range of "the physical phenomena in daily life" in Japan. "Experimenting with the water pressure and the atmospheric pressure, and connecting the result with the weight of water and the air" is the learning contents. We produced a small animal's water server as teaching tools for the introduction activity. This water server can visualize atmospheric pressure, have practical utility, and be made by low cost. A circular laboratory dish-like container of 180mm in diameter 20mm in height with a column formed a female screw of 28.5mm outside diameter 26.5mm inside diameter pace 3mm inside of a column, and the end of the column opened a water-air exchange hole. All of the parts were designed by using of an open-source parametric modeler FreeCAD, and printed with the FDM-type 3D printer MUTOH MF-1000. The materials are ABS and the

mass is 200g. The material cost was 3 USD. When using this tool, pour water into the plastic bottle, attach dish in substitution for a bottled cap, reverses upper bottom, wait until the water rises in a dish. Cats or dogs can drink water from the dish, and the shorten water is filled by plastic bottle. The water surface position of inside the bottle and that of inside the dish are different. So the learners can grasp the existence of the atmospheric pressure visually and recognize the mass of the air easily. This CAD data could be published so the learners can modify and apply the water server's data freely. [Draft]

[26O2G-3] Simple Analogical Tool for Teaching Electrophoresis (*A0374*)

Katsuki Izumi*+ and Masaharu Takemura

Department of Mathematics and Science Education, Tokyo University of Science, Japan

ABSTRACT Gel electrophoresis of nucleic acids is an important technique used in molecular biology and life sciences. The DNA length is determined by the number of base pairs that are negatively charged. They move toward the anode while exposed to an electric field. The short DNA move faster than the longer DNA because they receive less dynamic resistance from the gel. These principles of electrophoresis can be understood easily by researchers or teachers. However, it is difficult for students who have not learned physics to imagine that short DNA move more quickly than longer DNA. For this study, we developed a simple analogical tool for explaining the principle of DNA gel electrophoresis using a neodymium magnet and steel spheres. To visualize sample length differences, we used steel spheres as samples instead of DNA. Therefore, as a driving force, we used magnetic fields instead of electric fields. We connected two spheres with adhesives (doubly connected spheres), with three spheres also adhered similarly (triply connected spheres). These connected spheres were embedded into 0.5% agarose gel. The location of embedding is about 10 mm distant from the gel edge. Then a neodymium magnet was put at the gel edge. Doubly connected spheres first reached the neodymium magnet. Then triply connected spheres reached it within several minutes. Results show that this tool can express that small samples move faster than larger ones. However, the spheres move very slowly or did not move at all when the location of embedding was further than 10 mm distant from the gel edge. In conclusion, we developed a simple and novel analogical tool to teach electrophoresis principles to students, and expressed it successfully. Our model can help students understand electrophoresis principles even if they are unfamiliar with dynamics. Moreover, our model is potentially applicable not only to teaching electrophoresis principles but also to teaching dynamics in physics education.

<2H> Mathematics Education

Chair: Hisashi Otsuji (Toyo University)

[26O2H-1] On the Mathematics of Hairbraiding (*A0012*)

Dolly Rose F. Temelo*, Jolly Ann Blanco, Ana Mae Inocencio, Alfria Margarejo, Arje Jun Valzado, and Mark Anthony Vargas

West Visayas State University, The Philippines

ABSTRACT This study aimed to determine the mathematical applications – the mathematical structures and patterns of the five hair braids; three-strand braid, French braid, lace braid, waterfall braid, and fish tail braid. Through execution, investigation and observation the mathematical pattern and the mathematical structures were identified for each of the pattern. Patterns were formed by the repetition of the unit motif in a set of iterations. Mathematical patterns of the first three hair braids; three – strand, french and lace braid; were analysed according to the arrangement of the three groups of strands using the concept of permutation. Since there are 3 groups, the different arrangements made by taking all at a time are 123, 213, 231, 321, 312, and 132. These can be represented by notation n!, where the groups are distinct object. The arrangements can be expressed as n!=3!=6. The mathematical pattern of the waterfall braid repeats in every 6 of its iteration from 3rd to 8th iteration, the application of congruence modulo was used to define a function for the repeating pattern. The mathematical pattern of fishtail braid is defined by dividing the hair into two major divisions, X and Y, and these two divisions were divided into divided again into x_i, y_i where i is the number of equal subsets, and it takes i number of iterations to interchange the position of x_i and y_i and 2i number of iterations for the two subsets to return to its original position, considering that in every iteration, subset transferred to the other set cannot be transferred back to its original set unless i iteration is finished. The mathematical structure of the three – strand, french and lace braid is piecewise defined function: (omit) The mathematical structure that defines the mathematical pattern in the waterfall braid is: (omit) And the mathematical structure that defines the mathematical pattern in the fishtail braid is: (omit) Concepts in Linear Algebra specifically Matrices, Congruence Modulo, Sets and Piecewise Functions in Algebra, Geometrical Transformations in Geometry and Recursion in Discrete Mathematics were used to describe the mathematical structure of the five different hair braids. Mathematical structures of the five different hair braids were defined by Piecewise Functions, Congruence and Recursion. And frieze group was also used to identify the mathematical structures formed by the five hair braids. It was found out that the mathematical patterns and formulated the mathematical structure applying the concepts in Discrete Mathematics, Geometry, Linear Algebra, Number Theory and Advance Algebra. [Draft]

[26O2H-2] Teaching Concepts and Use of High-order Cognitive Strategies in Mathematics among Secondary School Teachers (*A0108*)

Effandi Zakaria*+, Norhidayah Addenan, Siti Mistima Maat, and Norazah Mohd Nordin

Faculty of Education, Universiti Kebangsaan Malaysia, Malaysia

ABSTRACT This study was conducted to identify the level of emphasis of teaching mathematics on the understanding of the concept and high-order cognitive strategies. A total of 15 teachers from four schools in Pasir Gudang, Johor were selected as respondents. Selected teachers were teachers who teach Mathematics for Form Two students. The instrument used in this study was a checklist with a 5-point Likert scale and an interview protocol. This checklist has two parts, Part A on the background of the respondents and Part B on the observation of respondents while teaching

which contained 21 items. Data obtained from observations were analyzed using descriptive statistics such as mean, frequency and percentage. The findings from the interview were also analyzed to help the researchers make an explanation. The findings showed that the mean of teacher emphasis on understanding the concept and meaning in teaching mathematics was moderate (m = 2.98). The teachers emphasis on the use of high-order cognitive strategies in the teaching of mathematics was also moderate (m = 2.79). These findings have implications for mathematics teachers to always have effective teaching strategies and can help to improve higher-order thinking skills in students.

<2J> Informal Settings
Chair: Pin-Hsuan Wu (National Taiwan Normal University)

[26O2J-1] Using Multiple Teaching Strategies to Improve In-service Teachers' Understanding of Buoyancy and Ship Stability (*A0132*)

Tso-Chung Sung[1+]*, Chia-Cheng Yeh[2], Min-I Lin[2], Wen-Jian Su[2], and Li-Shu Chen[2]
1. Exhibition & Education Division, National Museum of Marine Science & Technology, Taiwan and 2. Department of Systems Engineering and Naval Architecture, National Taiwan Ocean University, Taiwan

ABSTRACT Buoyancy and ship stability are the two critical factors why a ship can sail the ocean without sinking. Though, most of in-service teachers lack of proper way introducing to students both factors. In this study, a multiple teaching strategies for introducing ship technology, buoyancy and ship stability, were designed and implemented for enhancing the abilities of marine education of 27 in-service teachers (which teaches at elementary schools, junior-high schools or senior-high schools individually) at National Museum of Marine Science & Technology (NMMST) in Taiwan. The multiple teaching strategies included a hands-on activity and several operable teaching aids to demonstrate the impact of buoyancy and ship stability of ships. The hands-on activity is a DIY-course on making of a power-free autonomous underwater glider. The operable teaching aids included a simple boat demonstration module, a floating-sinking demonstration module, a transverse ship stability demonstration module, and a free-surface demonstration module, and etc. In order to understanding the effect of multiple teaching strategies, a pretest/posttest questionnaire (with 24 items in 3 sub-constructs included buoyancy, ship stability, and both buoyancy and ship stability etc.) was also applied in this study. The Cronbach's α value of the questionnaire is 0.84. The results showed the mean of the pretest was 12.48, and the posttest was 17.78. The improvement rate of the total score of posttest reached 42.5%. The progression of in-service teachers' understanding not only can be found in the mean score but also in 3 sub-constructs. The results show that teaching concepts of buoyancy and ship stability with the multiple teaching strategies proposed for in-service teachers on marine science and technology should be a practical way.

[26O2J-2] Science Edu-communication: An Exploration of the Impact of Science Education Initiated Television News on Learners' Perceived Awareness, Enjoyment, Interest, Opinion Formation, and Understanding (AEIOU) (*A0161*)

Pin-Hsuan Wu, Leon Yufeng Wu, and Chun-Yen Chang*[+]
Science Education Center, National Taiwan Normal University, Taiwan

ABSTRACT We proposed and practiced a model "Science Edu-Communication (SEC)" wherein science education initiates and plays a role as the facilitator between journalists and scientists to produce science communication productions, in various forms, such as Television News. The current study utilized the SEC-produced TV News aimed to explore the impact on the participants' perceived experience in science communication, termed as AEIOU: Scientific Awareness (A), Enjoyment (E), Interest (I), Opinion Formation (O), and Understanding (U). Further, the participants' High and Low Scientific Literacy in Media (SLiM) was also collected and analyzed as HS/LS to better understand their associated AEIOU. By comparing the responded AEIOU from two conditions : participants did not watch the SEC videos but used their daily experience from normal science communication atmosphere, and participants watched the SEC videos, we found that the Low SLiM SEC participants gained "Interest" and "Opinion Formation"; High SLiM SEC participants gained "Understanding" after watching the news videos. Audiences' media experience of science communication have been less studied empirically in the literature. The presented study shall provide insights for the current stage of research in the fields of science communication, science and media education.

[26O2J-3] Cool Japan's Science Culture (*A0401*)

Masataka Watanabe*[+] and Tsuyoshi Hosoya
University of Tsukuba, and National Museum of Nature and Science, Japan

ABSTRACT This article reviews and reflects over the influence of pop culture on public science literacy in Japan. A science boom unfolded in Japan in the late 1960s riding on a wave of high-speed economic growth. Since then Japan has also nurtured a unique pop culture in relation to science. It includes anime (Japanese animated cartoons and movies) and manga (story-telling comics in Japanese style). Usually such pop culture is considered low culture and having no impact on public science literacy. However, some Japanese pop culture has played an important role in raising public science literacy and interest in science and technology careers. The contents of manga are very diverse and range from nonsense stories to very serious ones. Science has also been steadily making inroads into manga. Recently a new trend has appeared in manga, which I'd like to call "scientific literate manga." A typical example of this new trend is the manga Moyasimon: Tales of Agriculture. It is very popular in Japan and the story cleverly introduces a wealth of knowledge about fungi and fermentation. It contains a lot of marginal notes that give factual information on microbiology and fermented foods. Twelve volumes have been published—two of them have been translated into English (Ishikawa, 2009, 2010). Total sales of the volumes exceed 4.5 million copies. Moyasimon has helped a rising boom of fermented foods in Japan.
Museum scientists and curators have also adroitly made use of Moyasimon in a special exhibition about fungi in 2008 at

the National Museum of Nature and Science in Tokyo. They featured many characters from Moyasimon in the exhibits, and the artist of Moyasimon visited the exhibition and drew some characters which were displayed behind the exhibits. The news of this quickly spread among younger generations via the Internet and the number of young people visiting the exhibition suddenly increased. The pattern of weekly number of visitors, we call it J type pattern, that means weekly numbers of visitors are almost same until the ninth week but they suddenly increased during the last two weeks. It looks very different with other scientific exhibitions' pattern, for example, the Darwin exhibition held in 2008 at the National Museum of Nature and Science in Tokyo. The usual pattern on weekly number of visitors is U type pattern, that means weekly numbers of visitors are very high during the first and the last a few weeks but relatively low during the middle of weeks. We will discuss about the unique pattern of visitors behavior and reflect about such an influence of pop culture to public science literacy. We can get a valuable suggestion from this analysis. We believe we should reconcile people's interest of pop culture and science culture.

<2K>Curriculum/Teaching Materials
Chair: Alan Hase (Saitama Institute of Technology)

[26O2K-1] Introduction of "Problem-solving Game Activities" into Science Education (*A0045*)

Alan Hase
Saitama Institute of Technology, Japan

ABSTRACT In recent years, almost everything that surrounds us now is digitalized and children do not get the opportunity to use analog devices because of the rapid advancements and convenience of information and communication technology. So, most children today no longer go outside or play outdoors, instead they only stay at home and play indoors with their video games, surf the web with their computers or handheld devices. Also, because of the unlimited information readily available on the internet, just by a single click, the need for remembering or memorizing and thinking is much less compared a couple of decades ago. In order to combat these problems, we should provide our children more opportunities to think and use their brains as well as use analog devices. Feeding our children with information by giving them lectures alone, in my opinion, is no longer sufficient in today's society. We need to be more creative on how we educate our children. We need to incorporate a more powerful teaching method and materials into our lectures to get their attention. Although these are primitive methods, using them would make students more engaged in class and learn more. So, I use problem-solving games in my lectures as a tool to get my students to participate in class more effectively. I will share with you my experience from one of the events I have organized where I have incorporated this style of teaching. By incorporating my method, students can immerse themselves in solving various problems (puzzles, quizzes and experiments) in a fun and exciting format like acting as a main character of a story. They get to learn the theory behind the material efficiently and pleasantly. Incorporating problem-solving games in class has three advantages. First, teachers get students' attention to listen and ignite their curiosities by introducing a story followed by a game. Second, teachers get students to think on their own. And, by doing activities on their own, they could develop their own way of thinking. Finally, incorporating these kinds of games in class could help students develop their communication skills and social skills because they get to work in groups. Targets for this event are mainly junior high or high school students, but sometimes I also organize this event to elementary school students and the general public. The teaching method of using problem-solving game activities and the survey done at the end of the event are described in this report. As a conclusion, I believe hands-on experience learning events through problem-solving game activities like mine are great and useful strategies to get students' attention and develop their communication skills and social skills. I think teachers as well as parents should give children more opportunities to use analog devices even if digital devices could be more convenient. From my experience and the feedbacks I have received from the survey I have performed, I have found that incorporating problem-solving game activities in classes or lectures greatly benefit students.

[26O2K-2] Simplified Electrophoresis Apparatus Developed for Effective Teaching Practices in High School Biology Class (*A0180*)

Masashi Kurabayashi[1]* and Masaharu Takemura[2+]
1. *Numata Girls' High School & Tokyo University of Science and 2. Tokyo University of Science, Japan

ABSTRACT In recent years, the development of molecular biology has been remarkable. Many techniques are becoming commonplace. Particularly, gel electrophoresis is a common molecular biology technique. Although this technique is widespread, the apparatus and materials necessary for the technique are expensive for high schools. Therefore, many high school biology classes have been unable to carry out electrophoresis experiments. This study was undertaken to facilitate the conduct of electrophoresis experiments in high school biology classes. We produced a simple gel electrophoresis apparatus at low cost. This apparatus comprises a silicone container (lunch box), pencil leads, six 9-V batteries, and wires with alligator clips. We were able to create the apparatus for about 500 yen. The gel itself is made from agar, which is readily available. As a sample, we use white nucleic acid extract, which is obtained using a simple DNA extraction experiment. To confirm the experimentally obtained results, we use fluorescent staining dye, two blue LEDs, and an orange acrylic plate. In practical lessons, students were able to conduct experiments smoothly, and were able to obtain suitable results. Responses to a questionnaire submitted to biology teachers suggest that our method of electrophoresis experiments is of practical use in classes. From these results, we conclude that this apparatus and the methods used are effective for facilitating electrophoresis experimentation in high school biology classes.

[26O2K-3] Activities and Research for Attracting Girls and School Teachers to Physics by LADY CATS and Science Teachers Groups (*A0204*)

Haruka Onishi*[1], Masako Tanemura[+2], Kyoko Ishii[3], Fumiko Okiharu[4], and Hiroshi Kawakatsu[5]
1. Higashiharima High School, 2. Osaka Kyoiku University, 3. Tamagawa

University, 4. Niigata University, and 5. Meijo University, Japan

ABSTRACT LADY CATS (LADY Creators of Activities for Teaching Science) is an organization of predominantly female science teachers from all levels of the educational system in Japan - from primary school to university. It was founded in 2004 and they have performed the workshop "Simple and Beautiful Experiments" at several international conferences since 2005[1]. In recognition of their contribution to international physics education, they were awarded the ICPE (The International Conference on Physics Education) medal in 2012[2]. LADYCATS build on the word of an earlier Japanese teachers group known as the "STRAY CATS" who demonstrated many experiments at international conferences for more than 20 years. They took over their core teaching which is "Everybody has a right to learn physics" and adopted part of their name. Each year, they organize workshops called "Simple and Beautiful Experiments" collaborating with male teachers at the conference, and sometimes educating high school students at the local schools. They work to encourage students and teachers to enjoy physics, through the production and presentation of simple and inexpensive science experiments that demonstrate the principles of Physics. In addition to the concept of STRAY CATS, LADY CATS add "beautiful" to "simple" and "low-cost" experiments, from a female's perspective. It is one of our aims to attract female students' attention and open the door to Physics. The number of female physics teachers and researchers is small in Japan. Female physics teachers and researchers are in the minority. Simultaneously, many schoolgirls have little interest in physics. On the contrary, there are many female teachers in primary schools. Among those there are many teachers who are not comfortable with teaching Physics in primary and secondary school. Also, these teachers are usually too busy with other work to prepare experiments, so consequently few experiments are performed in classrooms. In addition there is not a lot of financial support available for the extra-curricular activities of physics teachers. The LADY CATS' aim to meet the challenge of minimizing the discomfort felt by many teachers regarding teaching physics. Their concepts are as follows: "simple" experiments which teachers around the world including Japan can easily utilize in their lessons, "beautiful" experiments which attract and interest children, and "essential" experiments which can demonstrate the principles of physics. They are not only visually appealing but will also help in their understanding of scientific ideas. They try to support and encourage teachers and students. In their workshops, they have chosen experiments that are well received by children in their own lessons or at events in Japan. The international conferences in which they have participated are ICPE 2015 (China), ICPE 2014 (Argentina), ICPE-EPEC 2013(Czech Republic), WCPE 2012 (Turkey), ICPE 2010 (France), ICPE 2009 (Thailand), ASE 2008 (Britain), ICPE 2007 (Morocco), ICPE 2006 (Japan), and ICPE 2005 (India).

<2L> Learners (Teaching/Learning)

Chair: Chanat Intakanok (Chulalongkorn University)

[26O2L-1] The Study of Game Competitive Anxiety, Gameplay Interest, Gameplay Self-Efficacy and Metacognition Related to the Performance of Covariation Reasoning (*A0211*)

Jon-Chao Hong and Chiung-Hua Chan*[+]

Department of Industrial Education, National Taiwan Normal University, and Institute of Department of Industrial Education, National Taiwan Normal University, Taiwan

ABSTRACT The purpose of this study is to explore the relationship of game competitive anxiety, gameplay interest, gameplay self-efficacy and metacognition related to the performance of covariation reasoning. The game "No Good (NG) Bread" was developed by Digital Game Learning Laboratory of National Taiwan Normal University, designed for senior high school students who have taken a half year of baking courses to apply their knowledge to solve baking problems. The data from 138 participants, aged between 16 and 17, were collected for the research of the Quasi-experimental design. In order to examine the effect of those interrelatedness among the variables. The study took online game as the research situation. Students have to fill up the online questionnaires, after they tried 20 minutes of the Game of NG Bread in once a week for six times. After collecting of the questionnaires, analysis by SPSS 22 and performing of structural equation modeling (SEM)-AMOS 21 will be used to make path analysis to get the result and conduct empirical analysis. The results of this study showed that gameplay self-efficacy, gameplay interest and meta- cognition in learning NG Bread was negatively associated with competitive anxiety. Gameplay self-efficacy was positive associated with gameplay interest. The results also suggested that enhancing gameplay self-efficacy in a specific task can eliminate anxiety and support players' interests to play the game in a competitive setting.

[26O2L-2] Enhancing Scientific Attitudes and Problem Solving in Middle School Students through Case-based Learning (*A0398*)

Chanat Intakanok* and Sara Samiphak[+]

Division of Science Education, Department of Curriculum and Instruction, Faculty of Education, Chulalongkorn University, Thailand

ABSTRACT This study aimed to investigate the effect of case-based learning on improving 9th grade students' scientific attitudes and problem solving. 80 ninth grade students from two classrooms in a high school participated in this study. One classroom was instructed by case-based learning; while the other was instructed by traditional teaching methods. The same teacher taught both of these classrooms. As a pre-test, the scientific attitude test was administered to both classrooms. As post-tests, the same scientific attitude test and scientific problem-solving test were administered to both classrooms. One-way ANOVA was used to assess the effect of case-based learning on enhancing students' scientific problem solving. In the experimental group, T-test analysis showed that the mean scores of the post-scientific attitude test was statistically higher than that of the pre-scientific attitude at the significance level of 0.05. The results showed that case-based learning was an effective method to improve students' scientific attitudes and problem solving. [Draft]

[26O2L-3] Poor Verbal and Visuospatial Working Memory of Students Induces Modality Specific Errors in Science Learning (*A0538*)

Yuki Harada[1,2*+] and Makoto Suzuki[1]

1. Graduate School of Science, Hokkaido University and 2. Research Fellow of Japan Society for the Promotion of Science, Japan

ABSTRACT Verbal input and thought process is required for the learning of all subjects and above that especially in science learning ability to process visuospatial information is required. The working memory (WM) operates behind both the processes of holding and processing of verbal and visuospatial information. Students' WM capacity (WMC) predicts the learning achievement better than IQ and it is called the learning bottleneck. However it still is not clear what kind of errors poor WMC in each of its modalities induces. For example, the students who have poor verbal WMC might stumble in linguistic activity, such as discussion and reading comprehension. And the students who have poor visuospatial WMC might stumble in sketch, drawing diagram and visual imagery processing. In this research we defined errors as various types of stumbling in science learning and we investigated what errors the poor verbal and visuospatial WMC causes in science learning. We created a questionnaire based on an interview with an expert elementary school teacher to measure the errors in science learning. It used a four–point scale. In addition, we measured the students' self-efficacy of each field of science learning (physics, chemistry, biology and earth science) to investigate the impact of poor WMCs on self-efficacy for each of these fields. The participants were 52 high school first graders. All of them had learned chemistry and biology since entering high school. But they were instructed to remember the knowledge in junior high school when they answered questionnaire. The results of the structural equation modeling suggested that learning achievement depends on both modality specific WMCs: verbal WMC explained errors connected to learning through verbal processing and calculation, and visuospatial WMC explained errors connected to learning through visual imagery and control of attention. Furthermore the results indicate a significant correlation between self-efficacy of all fields of science learning and the verbal WMC, but only between self-efficacy of physics and earth science and the visuospatial WMC. Results show that in each poor modality of the WMCs in students induce different errors in science learning and more closely that in physical and earth science field specific errors are affected by the visuospatial WMC.

Oral 3 (27th, 09:00-11:00)

<3A> Learners (Teaching/Learning)

Chairs: Hsiao-Ching She (National Chiao Tung University), Chang Fui Seng (Universiti Sains Malaysia)

[27O3A-1] Designing a Long-term Weekend Science Camp for Middle School Students in Rural Area (*A0044*)

Huei-Chih Chang*+ and Wen-Hua Chang

Graduate Institute of Science Education, National Taiwan Normal University, Taiwan

ABSTRACT Current educational policy in Taiwan encourages schools to provide science enrichment programs for students, in order to overcome the science achievement gaps among students from various areas. In this presentation we will report a team of four science teachers in two rural schools, led by one school principal, co-planed, enacted, and evaluated a science inquiry program for seventh and eighth grade students. The program was funded by the Ministry of Science and Technology and free for students. The self-recommended students from two middle schools located in Zhuangwei township and Su'ao township in Yilan County met with the teacher team one-half day every other week. The base of the program was in the Su'ao junior high school. The teacher team guided the students to generate research problems for doing science project. Twenty-five students proposed six project topics including Recycle in campus, Cooling down the automobile, Storage of electricity, Design an electric transportation system, Bookmarks, and Enzymatic browning. The students also practiced inquiry skills including Observing and Keeping logs, Searching and organizing information, Expressing and communicating, and Reflecting and revising the project report. The teacher team offered a variety of hands-on activities for students to frame investigation problems, search information, conduct experiments, keep observation logs, and write-and-revise reports. Students compiled their learning portfolios and co-wrote project reports for the duration of 16 weeks. At the beginning, the students were short of confidence and skills, however, under the guidance and encouragement of the teacher team, at the end of the program, all of the six project groups demonstrated and presented their results. Moreover, during enacting the program, the teachers were impressed by the students' enthusiasm in participating learning activities. A group of eight science teachers from different schools served as outside evaluators to review the students' performance. The evaluator teachers pointed out some weaknesses in the students' artifacts, such as identifying error sources and graphing the results. Reflecting upon the comments and suggestions, the teacher team proposed a revised enrichment program for the next semester.

[27O3A-2] Use Eye Tracker to Explore Science and Non-Science Major Students' Online Scientific Literacy Assessments (*A0273*)

Ting-Ting Yang, Hsiao-Ching She*, and Pei-Yi Tsai

Institute of Education, National Chiao Tung University, Taiwan

ABSTRACT This study was to employ eye tracker to explore 80 science and non-science major students' scientific literacy performance and eye movement behaviors during their online scientific literacy assessments. Two groups of science and non-science major college students participated in PISA 2006-associated scientific literacy assessments while synchronized eye-tracking system was used. In the scientific literacy assessment includes "identify scientific questions", "explain phenomena scientifically" and "evaluate evidence scientifically" domains. The results showed that the science major students significantly outperformed than to the non-science students, regardless of "identify scientific questions", "explain phenomena scientifically" and "evaluate evidence scientifically". Eye movement indicators further supported that the science major group allocated significantly greater attention than to the non-science group, regardless of "identify scientific questions", "explain phenomena scientifically" and "evaluate evidence scientifically". This study adds an evidence that the eye movement behaviors could reflect students' depth and performance of their cognitive processing during online scientific literacy assessment.

[27O3A-3] Assessment in Chemistry and the Role of Higher Order Thinking Skills (*A0310*)

Chang Fui Seng* and Mageswary Karpudewan
Universiti Sains Malaysia, Malaysia

ABSTRACT As teachers in secondary schools, we are increasingly aware of the need to enhance students' higher order thinking skills as these thinking skills are the major driver for students to apply learning in different context. The notion that students learn differently based on their ability resulted in students from one classroom having different learning progression. It is important for the educators to identify the level of higher order thinking skills of the students as this will help in designing learning strategies to achieve the learning goals. In this paper, the level of higher order thinking skills of Form Four science stream students was investigated and the role of higher order thinking skills in chemistry assessment will be discussed. The outcome of quantitative survey involving 35 students revealed that Form Four science students from one of the government school in the state of Penang possess lower level of higher order thinking skills. Less than 40% of the students participated in study exhibited the ability to analysis and less than 50% have the ability to synthesis and evaluate. Based on these findings some strategies to enhance students' higher order thinking are suggested.

[27O3A-4] Exploring Elementary Students' Concepts about Acids and Bases (*A0541*)

Yangsub Jung and Shinho Jang
Seoul National University of Education, Korea

ABSTRACT The main purpose of this study was to identify the characteristics of students' mental model regarding misconception about acids/bases. Another purpose was to find out what misconceptions sixth graders had in comparison with fifth graders who did not receive formal education regarding this topic. 94 fifth graders and 119 sixth graders participated in this study. Each subject received a questionnaire that requires drawing, selecting alternative concepts and classifying acid-base. Among these students, 7 fifth graders and 9 sixth graders provided unique concepts and accurate responses to the questions. These students were then selected to participate in interview later. Analysis of the data informed the possible factors to explain students' misconceptions in acid/base: (1) human error by misinterpreting information processed from the four senses (touch, odor, vision, taste), (2) misinterpretation of the letter in acid/base, (3) overgeneralizing chemical property of acid and base, (4) incorrect inference about acid and base having opposite properties with one another. Some sixth graders have mistaken diluted hydrochloric acid(HCl(aq)) or common sprite for a basic solution. In the mental model of misconception, such mistakes were caused by human error from senses and misunderstanding particular terms. Also, among alternative concepts regarding acids/bases, sixth graders had significantly more information about common color of acidic/basic solution and their opposite properties than the fifth graders. In the mental model of misconception, such difference is related to visual error associated with the colors, and making incorrect inference that acids/bases have opposite properties with one another. This study will give us a chance to think about how the characters of misconception would be helpful for instructing students to have better understanding of scientific concepts.

[27O3A-5] Investigating High School Students' Chemistry Representation Competences (CRC): Understanding Properties and Structures of Covalent Substances (*A0497*)

Zhijun Xu and Maurice M. W. Cheng
Faculty of Education, The University of Hong Kong, Hong Kong

ABSTRACT Concepts related to "chemical bonding, properties and structure of substances" have known to be difficult to secondary students. Success in learning entails interpreting, translating, and selecting various representations, inventing new representations, and identifying differences between representations and their referents. These skills are called Chemistry Representational Competence (CRC) in this study. However, little is known about CRC among secondary students. This study investigates high school students' CRC in the context of understanding properties and structure of covalent substances. This qualitative study consists of two parts. Firstly, two written instruments, one on water and the other on graphite and diamond, were administered to two Year 11 classes, total 24 students in a secondary school. Then, from each class, a low-, medium- and high- achieving student from the instrument, were invited for a 45-min clinical interview respectively to explain their answers both verbally and by drawing. In this presentation, we will explicate the CRC framework, and its relevance to the learning of properties and structures of covalent substances. Findings from multimodal analysis through the CRC framework will also be reported. We observed that students demonstrated different levels of the same representational skills in this study. The model of CRC shed light on the enhancement of students' representational skills so as to facilitate their learning of abstract concepts.

<3B> Teacher Education (Teachers)

Chairs: Ebru Kaya (Bogazici University), Wei Yan Ling (Beijing Normal University)

[27O3B-1] Nature of Science in Pre-service Teacher Education: Learning to Teach Epistemic Practices of Chemistry (*A0016*)

Ebru Kaya[1*+] and Sibel Erduran[2,3]
1. Bogazici University, Turkey, 2. National Taiwan Normal University, Taiwan, and 3. University of Limerick, Ireland

ABSTRACT Nature of Science (NOS) is a significant area of research in science education (e.g. Allchin, 2011; Duschl & Grandy, 2014; Erduran & Dagher, 2014; Irzik & Nola, 2014; Lederman Abd-El-Khalick, Bell, & Schwartz, 2002) Conventional characterizations of NOS have relied on what is commonly referred to as the "consensus view". Lederman (2002) presented the key aspects of "consensus view" of nature of science. Although many researchers support these aspects, some researchers have pointed out some limitations of the "consensus view" of NOS (Allchin, 2011; Duschl & Grandy, 2011; Grandy & Duschl, 2007; Irzik & Nola, 2011; Matthews, 2012). For example, Allchin (2011) argued that the consensus view does not present science as a whole. Erduran and Dagher (2014) proposed and extended framework on NOS called the "Family Resemblance Approach" (FRA). The authors argue for a holistic approach to NOS which is promoted through FRA. In other words, the

FRA-based NOS covers a range of aspects of science including aims and values, methods, practices, knowledge as well as social-institutional dimensions of science. In this framework, epistemic practices are envisaged as an aspect of NOS. Epistemic categories such as data, models, explanations and predictions are subsumed within practices of science. This paper will illustrate how epistemic practices of chemistry can be infused in pre-service teacher education and thus contribute more broadly to studies on NOS in teacher education. The project reported in the paper aimed to develop teaching activities based on FRA and investigate the effect of FRA based NOS approaches on pre-service chemistry teachers' perceptions and understanding of NOS general, and epistemic practices in particular. The study is based on a project based at a university pre-service teacher education programme in an urban setting Europe. The programme lasts for 5 years and includes both subject and pedagogy modules. A total of 15 female pre-service science teachers participated in the project and 4 of these were chemistry education majors. Data sources were individual interviews and NOS questionnaires with pre-service chemistry teachers. Case studies of 4 pre-service chemistry teachers are highlighted. Results suggest that the FRA-based NOS framework used in the study contributed to pre-service teachers' understanding of NOS and epistemic practices of chemistry in a holistic fashion. For instance, even though pre-service teachers can typically exhibit understanding of epistemic practices such as the role of data, experiments and observations, they tend to have limited knowledge of how these aspects contribute to modeling or predictions in a holistic way. The results suggest that the teacher education intervention facilitated pre-service chemistry teachers in relating these epistemic aspects to each other. Furthermore, the qualitative analysis of the graphic representations produced by the pre-service chemistry teachers indicate some improvement in their perceptions of NOS. For example, while some pre-intervention representations had linear accounts of scientific practices, the post-intervention representations had more circular and holistic accounts. Overall the paper contributes to understanding of how NOS can be incorporated in teacher education and in particular how pre-service chemistry teachers' knowledge of epistemic practices of chemistry can be enhanced.

[27O3B-2] Analysis on Factors Affecting the Result of the Process Skills Test in Science of Science Teachers (*A0559*)

*Irene G. Dela Cruz and Lani M. Garcia

Carmona Elementary School and Milagrosa Elementary School, The Philippines

ABSTRACT Developing the pupils' capacity to understand scientific concept and to apply their scientific knowledge in their daily lives is the primary goal in science teaching. In order to attain this goal, the science teacher should be the first to be fully equipped and knowledgeable in carrying out this plan. What the teachers know and what they teach reflect on the achievement of their pupils. In the recent National Process Skills Test in Science and Mathematics given to all Grades 5 and 6 public school teachers in the Philippines, it was found out that almost 95% of teachers in the Municipality of Carmona failed to pass the test. This study developed a special science program called Science Teachers Enhancement Program (STEP) using the A2S Venn Model (Advanced Activities, Scientific Inquiry and Scientific Values) with the 3As approach (Awareness, Acquisition and Action). This study aimed to evaluate the effectiveness of the program, STEP in the improvement of process skills of Grades 5 and 6 science teachers in the Municipality of Carmona, Province of Cavite from January to April 2016. Eighteen teachers were selected based on the result of the national test. A pretest and a posttest on Process Skills were given before and after the program. The program consisted of twelve (12) sessions focusing on the different process skills such as observing, classifying, comparing, inferring, predicting, measuring and communicating. The result of the study showed that the program greatly contributes in gaining science concept and acquisition of science process skills. There was an 88.85% increase difference from pretest to posttest in the Process Skills Test. It also showed that the special program made a significant impact in providing an avenue for science teachers to widen their knowledge about content and to develop more of their interest in science through mentoring within the program.

[27O3B-3] What are the Differences between Japanese and German Forest Kindergarten Teachers' Qualification?: Comparison of their Institution Numbers and Learning Places and Contents (*A0169*)

Mina Goto

Doctoral Program in School Education, Graduate School of Comprehensive Human Sciences, University of Tsukuba, Japan

ABSTRACT Forest kindergartens (so called Mori-no-youchien in Japanese, and Waldkindergarten in German) attract international attention in recent years. Forest kindergartens are kindergartens for children between ages 3 to 6 and they stay outdoors all day long. The main activity is nature experiences. Children learn through interacting or playing with nature in all kinds of weather. Forest kindergartens have been around European countries throughout decades. Among others, in Germany, there are a lot of forest kindergarten in number and it seems to reach new heights of prosperity these days. This type of kindergarten has been increasingly brought to international attention with several reasons. One of related researchers discussed that the main reason is that children will have 21st century skills (such as thinking skills) or acquire nature knowledge through playing in and with nature, and some data demonstrate what the researcher exposed. Due to forest kindergartens are relatively new concept in Japan, we have several issues to solve. In regard to Japanese forest kindergarten, we have few in number compare to German case, but it increases steadily over the years. Within the increasing number of forest kindergarten in Japan, the Japanese Forest Kindergarten Association is facing various problems relating to ensure a quality of this education, and one of the core issues is about teachers' qualification. In this research, I argue the differences between Japanese and German forest kindergarten teachers' qualification by comparing their institution numbers and learning place and contents. In this research, German case was used to compare with Japanese case, due to its recent prosperity as mentioned above. Both Japanese and German forest kindergarten teachers' qualification systems were analyzed and compared from aspects of 1) number of their institutions, and 2) learning places and contents. These aspects were pointed out from using literature of all kinds,

data from participation in a seminar, and so on. In the result, following two things were figured out; First of all, there was a major difference between two systems, which was the number of institute for qualification. As for Japanese case, it has one institute. In contrast, German case, they have more than 4 qualification institutions. Second of all, there was a glaring difference between two systems, which was learning places and contents. In Japan, on one hand, teachers learn inside of a building, and they have lecture-oriented seminar which included a concept of forest kindergartens, risk management in forest, and so forth as learning contents. On the other hand, in Germany, teachers learn outdoors, mainly they had activity-oriented seminar for early childhood children in forest, and learned more about ecology as major learning contents. In conclusion, I discussed about possibilities and limits for further Japanese forest kindergarten teachers' qualification system.

[27O3B-4] In-Service Training of Science Teachers in "Diagnosis-Design-Implementation-Evaluation" Model (*A0237*)

Yanling Wei* and Lei Wang
Beijing Normal University, China Mainland

ABSTRACT Science teachers play a key role in making education successful, so they need ongoing professional development opportunities in order to better align their teaching with the expectations for students science learning. To promoting teachers professional development, different programs emphasize content knowledge, pedagogical content knowledge, building communities of practitioners, and building on teachers' beliefs (Bell &Gilbert, 1996; Marx et al.,1998;NRC,1996; Supovitz & Turner, 2000; OECD,2014). The studies of science teachers' training focus on (1) how teachers developed professionally, (2) how successful professional developers plan and implement teachers training programs, (3) the relationship between teachers and teachers training programs (Luft & Hewson, 2014). Our research focus the second point, and establish a set of in-service science teachers training system based on diagnosing the science teachers' teaching competencies. Science teachers' teaching competences are formed with a 5-20-4 model in this study. The 5 first-level dimensions of science teachers' teaching competences consist of the abilities of "understanding the discipline contents and values", "analyzing students' development spaces", "developing teaching objects and assessments", "designing teaching processes" and "teaching practice in class". Each first-level dimension is composed by four second-level dimensions, and these 20 key elements can be used as diagnosing indicators to diagnose science teachers' teaching competences. Each indicator is described by teachers' performance in a 4-level scoring system of excellent, good, pass and fail. Based on the 5-20-4 model, we propose the in-service science teacher training model, "Diagnosis-Design-Implementation-Evaluation". 'Diagnosis' is represented that diagnosis tools are developed by experts based on the 5-20-4 model and diagnose the teaching competencies of teachers who will attend the training project. 'Design' is represented that the training programs are designed on the basis of the diagnosis results. 'Implementation' refers to that the targeted training contents, activities and way are implemented in the light of diagnosis result of every teacher. 'Evaluation' refers to that teachers teaching competencies are diagnosed once more at the end of training projects. We had carried out in-service teachers training projects (146 chemistry teachers) on difference teaching topic guiding by the model of Diagnosis-Design-Implementation-Evaluation in four districts in China(All of the projects are supported by the foundation for formulating in-service teachers training standards of the Ministry of Education of China). The effectiveness of trainings was analyzed using descriptive statistics and T test, and the data was significantly differences. The teachers' abilities of understanding the contents and values of disciplines, designing teaching processes were significantly differences progressive after the trainings. The trainings promoted the teachers' abilities of analyzing students' development spaces of discipline study, developing the teaching objects and assessments, designing and implementing teaching processes also. Combining with analyzing the questionnaire after training, we found that: (1) the training objectives, training content may focus on the science teaching practice needs were designed step by step, (2) the learning community may be exactly built, (3) the training activities may carry out specifically and targeted to the learners, (4) the evaluation of training efficiency may be more detailed.

[27O3B-5] Study on the Composition and Evaluation of Pre-serve Chemistry Teachers' Instructional Design Capability (*A0483*)

Jiuhua Hu, Xuan Wang*, and Liqin Yuan
College of Chemistry, Beijing Normal University, China Mainland

ABSTRACT It's a trend to raise the pre-serve teacher education standards. So plenty of researchers focus on pre-serve teacher education. It proves that instructional design capability of pre-serve teachers is more easily improved than other instructional ability. Because they have little access to actual classes and students in university. Furthermore, pre-serve teachers usually design a class based on experience and lesson plans online. So they need to understand the teaching content, learn and apply modern teaching conceptions and strategies to create an excellent class. In a word, the training of instructional design capability is significant. Researchers have tried to find some ways to improve the ability. But the composition and evaluation of research about it are very little, and the study in chemistry is still blank. This study built a composition model of the pre-serve chemistry teachers' instructional design capacity, and developed two assessment tools for the capacity. The model and tools would contribute to the measurement and training of pre-serve chemistry teachers. Study Design: (1) Based on the early researches and analysis about lesson plans of pre-serve chemistry teachers, we defined the first indexes and the second indexes of pre-serve chemistry teachers' instructional design capacity: attitude and awareness (the effort of instructional designing, confidence of finishing the design, and the importance of instructional design), knowledge in chemical instructional design (general pedagogical knowledge, curricular knowledge of chemistry and pedagogical knowledge of chemistry), and skills of chemical instructional design(analysis, design and evaluation). (2) We divided the levels of each indexes by interviews with experts and analysis about lesson plans of pre-serve teachers. (3) Combined the indexes and levels to construct

the composition model of the pre-serve chemistry teachers' instructional design capacity. (4) According to the model and indexes, developed the assessment tools (an adapted lesson plan and a self-designed five scale questionnaire). (5) Conducted 1st test (255 junior and senior chemistry students from two university). Then processed data by Rasch, and verified the reliability, validity and difficulty. Based on the result, optimize the tools. (6) Conducted 2nd test (79 junior chemistry students). Perfected tools again and verified the model. (7) Analysed test result. (8) Ultimately identified assessment tools. By analysing the collected data, we revealed the following conclusions: (1) Overall, the first indexes and the second indexes of the pre-serve chemistry teachers' instructional design capacity is reasonable, and the levels of each index is also appropriate. (2) By processing data on Rasch, we found that the two assessment tools are successful, which can be applied to large-scale tests. (3) We divided the pre-serve chemistry teachers' instructional design capacity into 4 levels, and found that most of the pre-serve chemistry teachers are in level 3. Currently, we are describing the levels in every stage of their instructional design capacity development based on the model and tools. Then combined it with the interviews of pre-serve teachers and teacher educators, we will put forward specific and effective strategies to optimize the teacher education and contribute to the professional development of pre-serve teachers.

<3C>Learners (Curriculum/Assessment/Policy

Chairs: Jiwon Lee (Korea National University of Education), Sang Sang Liew (University Sains Malaysia)

[27O3C-1] Science for Citizenship Model (SCM): Assessing the Effects of Benefits, Risks, and Trust for Predicting Students' Interest in Science-related Content (*A0103*)

Brady Michael Jack, Ling Lee*, Kuay-keng Yang, and Huann-shyang Lin+

National Sun Yat-sen University, Taiwan

ABSTRACT This study showcases the Science for citizenship model (SCM) as a new instructional methodology for presenting to secondary students science-related technology content related to the use of science in society not taught in the science curriculum, and a new approach for assessing the intercorrelations among three independent variables (benefits, risks, and trust) to predict the dependent variable of triggered interest in learning science. Utilizing a 50-minute instructional presentation on nanotechnology for citizenship, data was collected from 301 Taiwanese high school students. Structural equation modeling (SEM) and paired-samples t-test were used to analyze the fitness of data to SCM and the extent to which a 50-minute class presentation of nanotechnology for citizenship affected students' awareness of benefits, risks, trust, and triggered interest in learning science. Results of SCM on pretests and posttests revealed acceptable model fit to data and demonstrated that the strongest predictor of students' triggered interest in nanotechnology was their trust in science. Paired-samples t-test results on students' understanding of nanotechnology and their self-evaluated awareness of the benefits and risks of nanotechnology, trust in scientists, and interest in learning science revealed significant differences between pretest and posttest and provide evidence that a short 50-minute presentation on an emerging science not normally addressed within traditional science curriculum can significantly impact students' learning of science in the classroom. Finally, we forward why the results of this study may be essential to science education instruction and research for understanding how the integration into classroom science education of short presentations of cutting-edge science and emerging technologies in support of the science for citizenship enterprise might be accomplished through future investigations.

[27O3C-2] The Survey and Analysis of Grade Eight Students' Understanding about the Concept of Global Warming (*A0172*)

Lin Jing

China Collaborative Innovation Center of Assessment toward Basic Education Quality, Beijing Normal University, China Mainland

ABSTRACT Atmosphere and environment are the two critical issues that concern our humans; meanwhile, they are also important contents for the science curriculum of basic education in many countries. Chinese students learn about the composition and pollution of atmosphere and the interaction between human activities and environment in science classes of grade seven or eight. Relating the real world contexts and taking global warming as assessment contents, this study aims to figure out students' awareness and ability to apply what they have learnt in science classes to the real life. Therefore, to some degree, this study reveals the effect of science education reform on the transition from knowledge-oriented science education to literacy-oriented science education. The research questions are focused on the following three aspects: first, students' understanding about the concept of global warming, including its phenomena, causes, damages and how to control it; second, students' understanding about daily energies and their usage; third, students' information sources about the global warming. 37 grade eight students are randomly sampled, including 21 males and 16 females, from 10 secondary schools in a southern city of China (4 in urban areas and 6 in rural areas). These students have learnt the curriculum contents of atmosphere, climate, energy, environment, and human activities in grade seven and eight. These curriculum contents are related to global warming, but not the concept of global warming itself. Students are semi-open interviewed by researcher one by one for 15-20 minutes. According to the notes and records of the interviews, a series of work then are conducted, including text entry, classifying, coding, and data inputting. Finally, the results are processed by SPSS. Results show that students' understanding about global warming mainly focuses on the concept of heat. 24 students think that the heat resulting in the global warming is related to the emitted carbon dioxide; 10 students think that the heat is related to the ozone depletion; 9 students also consider that the excessive heat from burning leads to the global warming; and 10 students attribute the global warming to the human factors and environmental destruction. Only 2 students describe and explain the global warming in the correct way. Besides, students' understanding about daily energies mainly focuses on electricity and coal. Only 17 students know energy utilization. As for the harm of global warming, most students mention that the sea-level rise will flood some places. When it comes to how to control the global warming, most students talk about in general terms, such as reducing

the use of cars, electricity, coal and disposable chopsticks, saving water, not littering around and so on. The data of this research also show that Internet, books, TV and news are the major resources from which students get information about global warming. Only 3 students mention classes and classmates. These results remind us that both schools and mass media need reform and improve science education and popularization, thus enabling students to achieve better scientific literacy.

[27O3C-3] A Comparative Study on Scientific Integrity, Perception of Scientific Misconduct and Requests of the Research Ethics Education between Korean and Japanese Gifted Students (*A0383*)

Jiwon Lee[1]*, Jung Bog Kim[1], and Tetsuo Isozaki[2+]

1. Korea National University of Education, Korea and 2. Hiroshima University, Japan

ABSTRACT In this article, we analyze Scientific Integrity, Perception of Scientific Misconduct and Requests of the Research Ethics Education of Korean and Japanese Gifted Students to address three questions: First, how well do students keep research ethics in their own research process? Second, how do students perceive scientists' misconduct? Third, do students want to learn research ethics education? If so, which specific contents (aspects/categories) do they want to learn? Participants were 397 Korean and 370 Japanese science gifted high school students. The survey results of their scientific integrity showed that 48.92% of Korean students were experienced at scientific misconduct on their own research, while 14.86% of Japanese students did scientific misconducts. Their perception of scientific misconduct, however, almost all student, 90.61% of Korean students and 87.54% of Japanese students already knew that the items mean scientific misconduct. Even if the students say that they know the scientific integrity, but they still commit scientific misconduct, that actually is not really knowing it. The results of their requests of the research ethics education showed that 32.94% of Korean students answered that they wanted to learn about research ethics, while 19.63% of Japanese students wanted to learn it. Not only the concept of research ethics, but the practical issues which occurred in research progress were the contents specifically what they wanted to know. In order that gifted educators can help students do their research ethically, the former have to reflect on the real condition of the gifted students' scientific integrity, perception of scientific misconduct and requests of research ethics education that are clarified in this study.

[27O3C-4] Identifying Junior High School Students' Misconceptions about Characteristics of States of Matter in Cambodia (*A0413*)

Sreypouv Ouch and Kinya Shimizu

Hiroshima University, Japan

ABSTRACT Many students at all levels struggle to learn chemistry, but are often unsuccessful. One premise is that students are not constructing appropriate understanding of fundamental concepts from the beginning of their studies. What students learn, are the results of interaction between what is brought to the learning situation and what is experienced while in it. States of matter, one of the highly abstract concepts in Chemistry, describe the level of particle. Students have difficulties in understanding particles when they are explaining the physical properties of matter base on particle concept. Several researchers have discovered students' misconceptions on this concept, and surmised that new knowledge of science cannot be gained if students still think their naïve ideas make sense. If teachers are using traditional teaching strategies in teaching science, students do not have the opportunity to confront their misconceptions and reconstruct their knowledge. Educational Strategic Plan (2014-2018) in Cambodia is focused on strengthening the quality of science education and scientific research. In Cambodia, states of matter have been taught from grade 1 to grade 7 while teaching and learning mostly follow teacher-centered. We do not know what ideas that students bring to classroom through traditional methods. According baseline survey report, teaching science in secondary level fail to stimulate scientific thinking. Regarding the effectiveness of learning science, it is important to know students' experiences including misconceptions, however, there is no research on this in a Cambodian context, so this study should be conducted. This study aims to examine the trend of students' misconceptions on the Chemistry topic of "States of Matter". To be more specific, the "States of Matter" theme to be examined incorporates three elements: 1) particle characteristics, 2) physical properties, 3) physical changes of solids, liquids, and gases. To achieve the above mentioned research purpose, the study use an instrument called "two-tier diagnostic test," adopted from previous studies. To obtain content validity, the adopted instrument was adjusted to fit Cambodian curriculum and students' level of competence. The instrument consists of two parts: the misconceptions and the justification part. The misconception section seeks to measure the level of students' misunderstanding on the focused topic. The justification part asks them to give reasons for their answers. The expected number of participants is approximately 200 students of grade 7 from four junior high schools in kampot province, Cambodia. The schools are selected purposively such that students of different backgrounds and level of competence are include in the sample. Because this study is based on quantitative philosophy, descriptive statistics and test of differences will be used to analyze data. Various statistical tolls will be used to check validity and reliability of the instrument and the analyses.

[27O3C-5] Assessing Students' Physics Practical Skills Using Two Different Modes of Assessment (*A0467*)

Liew Sang Sang

Universiti Sains Malaysia, Malaysia

ABSTRACT Practical work is inseparable with the learning of science subjects, especially in abstract subject such as physics. Practical work is believed to enhance students' understanding and at the same time helps to develop students' interest in learning. However, for practical work to be meaningful, students must possess good practical skills. As such, assessment of practical skills had always been included in high stake assessments of the science subjects. Different methods had been used to assess practical skills in the school laboratory, either through performance assessment, written reports or written tests.

Yet, different modes of assessment might yield different results. This paper discusses assessment of physics practical skills using two modes of assessment: hands-on practical task and written practical test. Practical skills were clustered into four different domains: Design, Execution, Analysis and Evaluation, in accordance the hypothetical-deductive model by Lawson, Abraham and Renner (1989). The purpose of study is to determine students' mastery level of physics practical skills in these two modes of assessment and thus compare the performance of students in these two modes of assessments. The hands-on practical task was assessed using direct observation while the written test was a paper-and-pencil test made up of constructed response items. For the purpose of this study, the two instruments needed were developed. The background of the study was set in the Kuching city, which was the capital city for a state in Malaysia. A total of 153 students aged 16 years old from ten secondary schools were involved in the study. Findings showed that most students have moderate level in mastery of practical skills. However, there was only weak correlation between the performances in two different modes of assessment. This result indicate that practical skills should be assessed with different methods, as students performed differently in different modes of assessment. This also suggests that practical skills are multidimensional.

[27O3C-6] Thailand – Japan Comparative Survey on Motivational Factors for Studying Science by Lower-Secondary Students (*A0572*)

Yasushi Ogura* and Benyapa Prachanant+

Saitama University, Japan and Chitralada School, Thailand

ABSTRACT Both of the levels of self-concept and self-efficacy correlate with students' achievement in general. PISA 2006 reported that average Japanese students showed high achievement in science and low level of self-concept and self-efficacy, while average Thai students showed low achievement in science and high level of self-concept and self-efficacy in science internationally. Why this opposite phenomenon occurs in international comparison has not yet been well explained. The purpose of this study is to explore and explain the relationship among achievement, self-concept, self-efficacy and other relevant factors concerning science learning in Thailand and Japan. We conducted surveys in each country in 2014 in which total of 2,344 Japanese and Thai eighth graders and 73 teachers responded to the questionnaires of common sets of questions across countries. Forty one questions were included in the student questionnaire from theoretical consideration. The results of factor analysis extracted six factors including self-concept, self-efficacy, praise-feedback, effort to achieve, environment, and achievement in both countries. By using these factors, different and common characteristics were analyzed for both countries. Confirmatory factor analyses were used to interpret the relationship and functions of the factors and socio-cultural difference between countries. Some possible explanations of the phenomena that appeared in the PISA will be discussed.

<3D> Learners

Chairs: Jennifer Yeo (Nanyang Technological University), Wang Kuo Hua (National Changhua University of Education)

[27O3D-1] Argumentation Level in On-line Argumentation among Cram School Students (*A0097*)

Chien-Fang Ku[1], Shu-Mey Yu[2], and Kuo-Hua Wang[3]

1. Graduate Institute of Science Education, National Changhua University of Education, 2. Department of Science Application and Dissemination, National Taichung University of Education, and 3. Graduate Institute of Science Education, National Changhua University of Education, Taiwan

ABSTRACT This study was designed to investigate the quality of argumentation, there are 24 seventh and eighth grade students to participate in on-line argumentation activities led by cram school teachers to explore the argumentation ability of students. In argumentation element analysis, elements defined in the Erduran classification adopted by Clark and Sampson (2007) was referenced. For the argumentation level, the theory of Osborne et al. (2004), Jiménex-Aleixandre & Pereiro-Muñoz (2005), and Sadler & Fowler (2006) was referenced. The study was conducted primarily through qualitative analysis and secondarily through quantitative analysis. The two issues, "anti-cancer detoxification meal" and "development of biomass energy in Taiwan", were the study tools. An anonymous blog was the platform for the subjects to complete questionnaires on the issues, synchronized and asynchronous argumentation, and reflective composition, etc. Each issue was open for discussion online for 33 days. After that, interviews were conducted with some individuals. The researcher and another graduate student with experience of argumentation analysis examined the consistency of element analysis and level analysis. The consistency of argumentation elements is between 87.2% and 93.4% while that of argumentation levels is between 97.5% and 95.6%. In argumentation quality level, Level 2 occupied a higher percentage in both issues. Percentage of lower levels, i.e. Level 0, Level 1, and Level 2, was higher in detoxification meal than biomass energy while percentage of higher levels, i.e. Level 4, Level 5, and Level 6 was higher in biomass energy than detoxification meal. According to the result of students' two argumentation levels shows that their performances on two argumentation levels tend to , first, the improvements on performances; second, the fall in performances, and third, the even with performances. Finally, the study explores the factors that affect the ability of students on participating in the performance of argumentation activities through analyses of students' performances and interviews to provide references for future research.

[27O3D-2] Mental Thinking Training for Attendees during Liquid Nitrogen Experiments Show (*A0350*)

Tengfei Ye and Hua Tian

Beihang University, China Mainland

ABSTRACT Liquid nitrogen experiments shows are welcome by attendees at Science and Technology museums. But usually the pieces of experiments are randomly mingled during the show. The paper tries to use Dewey's "Five-Step-Thinking Method" to arrange the sequence of liquid nitrogen experiments to ignite the mental thinking among the attendees at Science and Technology museums.

The so-called "Five-Step-Thinking Method" refers to guiding the attendees to observe the experimental phenomena, raise the questions, propose the hypothesis, reason, and verify with next experiment. And the next experiment will ignite the next round of mental thinking training. In order to achieve the above purpose, we did the following things: 1) Select the experimental materials from daily life so that the attendees feel close to the experiments. 2) Select the experiments that "contradict" to the common sense of the attendees to arouse the interests and thinking of the attendees. 3) Carefully use questions to call the attendees' attention to the phenomena set by the experimental performer. 4) Carefully analyze the attendees' answers and talks to help propose the hypothesis and reasoning. 5) Explain the verification experiments if necessary. With those activities, we designed a set of liquid nitrogen experiments with the sequence of "Liquid Oxygen", "Frozen Rubber Tube", "Sunk Tissues", "Blown Balloon", "Frozen Balloon", and "Frozen Grapes". We found that most attendees, including both elementary school students and the adults, can follow the steps of the logical thinking. If attendees were familiar with liquid nitrogen, they can help lead the conversations among the attendees. Some attendees needed reminding of the previous experiments to further the logical thinking. With the interviews after the experiments shows, we found the attendees loved the way of thinking training during the show and they learned a lot about the properties of liquid nitrogen.

[27O3D-3] The Examination of Impact of Interest in Science of School Stage on Adults' Scientific Literacy: Focusing on Decision-Making and Relevant Components (*A0086*)

Shotaro Naganuma

Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, Japan

ABSTRACT It goes without saying that scientific literacy is now regarded as an important goal of science education. The importance of scientific literacy is based on the situation that our society is surrounded by science and technology (S & T). In addition, S & T themselves cause some serious problems like global warming. Now we are living in the era when we are required to rethink about the use of S & T. Therefore, some international scientific literacy surveys for young students such as TIMSS and PISA are highly evaluated. In Japan, for instance, national achievement test has incorporated a new part (Part B) since 2012 to assess students' ability to use scientific knowledge and process, which resembled PISA, in contrast to Part A focusing on mastery of scientific knowledge and process. Also, the results of adults' scientific literacy survey using Oxford Scale developed by Jon Miller have significant suggestion for us. For example, in the United Kingdom, it fueled "public understanding of science" movement (Stocklmayer and Bryant, 2012). However, there are two points missed in these assessments. One is that both surveys for children (TIMSS and PISA) and adults (Oxford Scale) do not include item for decision-making although it has begun to be recognized as an essential components of scientific literacy (eg. Twenty-First Century Science, 2003: Kusumi, 2011). The other is that adults' scientific literacy is assessed mainly based on their scientific knowledge, while youth's scientific literacy is measured including scientific competencies such as identifying scientific question, explaining phenomena scientifically, and using scientific evidence. Therefore, the author developed original instruments to assess adults' scientific literacy from three perspectives: using scientific evidence, explaining scientific inquiry, and decision-making. 401 general citizens, 134 male and 267 female, participated in this study using the Internet Research System Nikkei Research. Participants were required to answer in the free description. All responses were assigned of minimum 0 point to maximum 2 or 3 points by three raters including the author. In order to score qualitative free description data, rubric was developed for this research. After checking whether all raters could reach allowable coincidence of scores, the median of three points for each response was used for the following study. We hypothesized that interest in science in their high school era affect adults' scientific literacy, analyzing this empirically with Path analysis. Interest in science was selected as an independent variable since it is commonly said to relate with adults' scientific literacy (eg. Tokyo Metropolitan School Personnel in Service Training Center, 2009). Also, interest in science in their high school era was focused since it is reported to decline dramatically at that era in Japan (Ogura, 2006). The results of statistical analysis indicated that the more interested in science in their high school age they were, the more interest in science they showed, which led higher scientific literacy of adults. This result suggests that enhancing interest in science of school children would improve their future scientific literacy, which corresponds with the recommendation of Shimizu (2006) that used Oxford Scale as a scientific literacy indicator.

[27O3D-4] Examining Students' Constructed Explanations in Thermal Physics (*A0333*)

Jennifer Yeo*[+] and Xiu Wen Tay

Nanyang Technological University and National Institute of Education, Singapore

ABSTRACT The ability to construct scientific explanations from laws (e.g., gas law) and theories (e.g., kinetic theory of gas) are expected learning outcomes of high school physics. We refer to them as interpretive and causal explanations respectively. However, studies (e.g., Hakkarainen, 2004) show that students' explanations tend to be formula-driven or intuitive. This study sought to examine students' constructed explanations to understand the nature of the explanations students produce, and the challenges they face. Scientific explanation can be described in terms of its function, form and level (of precision, abstractness and complexity) (Yeo & Gilbert, 2014). This study focuses on the type of explanation students produce (function), the model used (level of precision) and its structural organization (form). In a think-aloud context, the form of a scientific explanation reflects the reasoning process of the students in various modes of representations. In thermal physics, we can think about a phenomenon at three levels of precision: microscopic (kinetic theory of matter), macro (gas laws), and system (first law of thermodynamics). Using a think-aloud method, we interviewed 83 students after they had learnt the topic of thermal physics by asking them to produce an explanation of a phenomenon on adiabatic compression, with any mode of representations. Analyses include identifying the type of explanation produced and

the level of precision used. Analysis of form draws on Lemke's (1998) multimodal framework to identify the meanings produced and the process of construction. Findings show a larger proportion of students constructing interpretive (66.3%) compared to causal explanations (33.7%). For the interpretive explanations, two levels of precision were found: first law and gas law. Those who made use of gas laws were considered unsuccessful as the law was not appropriate in accounting for the phenomenon. This indicates a problem in selecting an appropriate level of precision to account for a phenomenon. The proportion of students constructing a successful interpretive explanation (34.5%) using first law of thermodynamics is more than that of causal explanation (14.3%), an indication that producing a causal explanation may be more difficult for students than an interpretive one. Analysis of the form of causal explanations indicates that its reasoning is more complex than interpretive ones. The former was found to involve the abstraction of the phenomenon into a pictorial model, and using the assumptions of particle properties to think about how their behaviors produced a series of cause-and-effects. The latter was found to entail the identification of formula, its quantitative properties of the variables, followed mathematical computation to link to the observed behavior. In producing a causal explanation, students often could not produce an appropriate model, while students' reasoning in interpretive explanations tended to be mechanistic rather than conceptual. These findings indicate the need to expand beyond conceptual understanding in developing students' competencies in producing scientific explanations in thermal physics, and to include the epistemic functions of different scientific models (levels of precision) and process of abstracting from a physical phenomenon (modeling).

[27O3D-5] Investigating Science High School 1st year Students' Identity Shift through R&E Participation (*A0503*)

Minjoo Lee* and Heui-Baik Kim+

Daejeon Science High School and Seoul National University, Korea

ABSTRACT Learning at the elbow of scientist is a well-known educational approach to improving students' understanding of science and scientific practice. R&E (Research & Education) is one of the representative Korean educational programs for scientifically gifted students, providing opportunities for long term authentic research experiences with scientists in laboratories. This study aimed to explore students' dynamic process of construction and reconstruction of identity through the R&E participation. It also focused on differences among students which influenced their various trajectories of identity construction.

Data from participant observation for 18 months and in-depth interviews with students were analyzed based on the constant comparative method to extract common characteristics of students' and their actual shifts in identities. Participants' narratives were also analyzed to better understand their identity shifts with the references of the author and receiver of a specific narrative identity. Research findings showed two different trajectories of identity development: (1) from novice student-participant to proficient student-participant, (2) from novice student-participant to beginning student-researcher. All students participated in the same program on an R&E team that provided the same institutional and personal support, but showed different identity trajectories. Enculturation of scientists' culture and practice, performances reflecting one's agency, and internal recognition of themselves as scientifically competent were analyzed to contribute students' development of identity as a student researcher. With these findings, this study have implications for designing educational programs that focus on participating in authentic research with scientists. First, in addition to experimentation with scientists, these programs should emphasize learning the specific culture of scientific practice, including reading academic journal articles, adhering to research ethics, and discussing with other researchers. Second, educational programs for promoting students' agency should empower students to take responsibility for some parts of the research, even if it must be under the instruction of scientists. The study's findings also have implications for designing research programs, especially for students who have already articulated science related careers but still have only foggy notion about science.

[27O3D-6] The Comparison of Scientific Communication of Primary Students in Mongolia and Korea (*A0560*)

Seongsoo Jeon[1]*, Kwang-Tek Oh[2], NamGwon Back[3], and Jong-Ho Park[3+]

1. Hoewon Elementary School, 2. JangJae Elementary School, and 3. Chinju National University of Education, Korea

ABSTRACT Korea and Mongolia made a cultural agreement in March 28, 1991 and then contracted to progress the educational cooperation program between the Ministry of Education in both countries in 2002. Now, after 14 years, the relationship between the two has been closely linked; educational exchanges also correspondently become more and more active. However, most of the researches were concentrated on Korean language, so comparison studies on curricula of two countries on the equal position were rarely found. Scientific communication competence refers to ability to deliver, share, and exchange facts, phenomena, and causes for explaining scientifically or proposing certain hypothesis as various communication forms based on scientific knowledge and literacy (Jeon, 2013). Additionally, such capacity can be defined as cross-curricula and delocalized one, and in developed countries, scientific curriculum definitely presents the objective and learning contents while that of few counties in Asia displays just the learning goals. Therefore, this paper aims to share educational implications on science education by comparing scientific communication capacity of students in Mongolia and Korea. To achieve this, targeting 300 elementary school students of Mongolia, 10~12 ages, and the same number of Korean primary school students with the same age, data was collected using the test tool for inspecting scientific communication skills (Jeon, 2013). In the body, the differences and types of scientific communication competence of elementary school learners in Mongolia and Korea would be discussed through specific educational variables of each country.

<3E> ASTE Session 1

Chairs: Winnie Wing Mui So (The Education University of Hong Kong), Todd M Milford (University of Victoria)

[27O3E-1] Professional Development of the Public School Teachers in Japan the Reflection (*A0525*)

Tomoki Saito

Graduate School of Science & Technology, Shizuoka University, Japan

ABSTRACT In this symposium, the author describes how Japanese teachers develop their own professional skills and how can we improve the opportunities to support novice teachers in the next generations. Over all, the teachers are provided training opportunities as the duty of their work and rarely make the additional training opportunity on their own. Thus the explanations include several facets of official training opportunities and the importance of their self-trainings. In Japan, teachers are the governmental agents who are working for the local city. Thus, there are several conditions which teachers should meet. One of those conditions, teachers have to study and train by themselves (Fundamental Low of Education, 2006revised). For this purpose, each board of education provides training opportunity for the teachers at the first year and the tenth year of their carriers (Some of the board provide it also in the second year and the fifth year). At the first year, the teachers provided to develop their professional carrier with the experienced teachers who are working as the officers in the board of education. These trainings are provided by the cities and the prefectural board of education. In these training, several novice teachers work with an experienced teacher to develop one or two lessons as lesson study which will be observed by many teachers from inside and outside of their school. Totally, they spend more than ten days per year for the training. Two times of them gather all of the novice teachers to the prefectural establishment for the training. Then these training provide the opportunities not only for the subjects like science, but also for the other many special classes which teachers are taking charge (e.g. Moral, Homeroom Activity, Time for Integrated Learning). Through these training in the first year, the novice teachers obtain their skills to develop the science lesson consistently and to run their homeroom with some special classes. From the second year, the training becomes more focused on science. Because they are assigned more works in their schools, the opportunities usually take two days per year and teachers plan and schedule their training by themselves during these two days. In addition to these provided opportunities, teachers allow to leave their schools to have some self-training. Prefectural board of education usually provides the opportunities in the establishment or the city board of educations also provides such opportunities with no duty. Furthermore, teachers held their self-training organizations and share their curriculum materials and/or their lesson plans for some units. Usually they discuss about the difficult experiments or new experiments among many of which had disappeared once because of the revision of the national curriculum. Like this, the teachers' preparation and development opportunities are well established by the board of education. Thus the teachers' opportunities are enough to develop their own professional skills. One of the retired teachers said, however, "The opportunities which they obtained by their own make them well prepared". The theories of learning also have suggestions here. The learner learns more when they want.

[27O3E-2] STEM Education in Bangladesh: Science Teachers Readiness to Make the Transformation (Bangladesh) (*A0428*)

Kazi Shahidullah

College of Education, University of Nevada, Reno, USA

ABSTRACT This paper explores the science teachers' readiness to transform science education practice into STEM education in Bangladesh. Current science education in Bangladesh has been going through a transition due to declining of students' enrollment, transmission based teaching-learning method, traditional science curriculum, instruction, and science assessment system, and lack of contemporary professional development. The current research was conducted among the in-service science teachers in middle school about STEM education readiness. This study has found that the teachers have lack of integration knowledge and skills of STEM-oriented materials, preparation, pre-service and in-service training, and integrated STEM-based practices. The survey has also found that the science teachers' preparation and teaching-learning equipment could be the ultimate factors for boosting the STEM education. Besides this, most of the participants agreed that the new STEM-based education will help the students to achieve problem-solving and critical thinking skills to become 21st-century citizens. This study has also found that science teachers are aware that the traditional science curriculum is not sufficient for applying STEM education in the classrooms. The teachers agreed that there had been some level of STEM education practice or interdisciplinary practice through science fairs or projects. Additionally, the teachers urged for appropriate curriculum and instructional use such as project-based, problem-solving based and multidisciplinary instructions, and laboratory facilities for implementing STEM education in their classrooms. [Draft]

[27O3E-3] Analysis of STEM Activities in Hong Kong Primary Students' Inquiry Projects (*A0104*)

Wing Mui Winnie So

The Education University of Hong Kong, Hong Kong

ABSTRACT The trend to extend science education to include STEM education in the US in the recent decade also takes place in many other countries in the world. In Hong Kong, the future development in education proposed in the Policy Address 2015 included: "The Education Bureau will renew and enrich the curricula and learning activities of Science, Technology and Mathematics, and enhance the training of teachers, thereby allowing primary and secondary pupils to fully unleash their potential in innovation (item 152)." However, the integration of science with technology, mathematics and engineering is still to be established and further research along this line is necessary. Therefore, this study attempts to analyze the written reports in an inquiry project event for a better understanding of STEM activities demonstrated by the primary students. The primary students' inquiry project reports were chosen from those 140 teams (with 4-5 members in a team) with 1000 primary students who were aged 10-12 participated in the 2015 "Innovations in Science and Environment Studies" event in Hong Kong. Under the main theme of "Go Green at Home", the participating teams had to present the processes and results of their inquiry projects and to submit a written report which recorded their ideas, methodology and inquiry processes and results.

10 project reports were randomly chosen from each group of outstanding, merit and consolation projects with a total of 30 projects being analyzed. Content analysis was first conducted to code STEM activities demonstrated in each project report. The coded data were then changed into numerical data for quantitative analysis. The results showed that more engineering and science activities were adopted than technology and mathematics activities in the inquiry projects. Outstanding group conducted more STEM activities than the merit and consolation groups and significant group differences existed in science and mathematics activities. Furthermore, science activities significantly positively related to engineering and mathematics activities in students' inquiry processes. The discussion of the paper will delineate a few examples of how science activities are linked to engineering and mathematics activities. This study sheds light on the pattern of STEM activities in students' inquiry processes and has implications for promoting STEM integration in primary education. [Draft]

[27O3E-4] The Prospect of Establishing the STEM Education Community in Malaysia: Recent Development in STEM and the Way Forward (*A0192*)

Muhammad Abd Hadi Bunyamin*[1,2], Corrienna Abdul Talib[1], Johari Surif[1], Nor Hasniza Ibrahim[1], and Nor Farahwahidah Abdul Rahman[1]

1. Universiti Teknologi Malaysia, Malaysia and 2. University of Minnesota, USA

ABSTRACT Integrated science, technology, engineering, and mathematics (STEM) is right on the embryonic stage in Malaysia. The recent development indicated that the Malaysian government via the Ministry of Education intended to adopt the idea of STEM integration in the latest education blueprint. However, the STEM movement in Malaysia is now facing many challenges because many teachers in STEM subjects like science and mathematics had not been trained to use integrated STEM during teacher preparation programs and professional development programs. In addition, there were numerous old issues in education that had not totally been solved like big class size, financial constraints, high teacher's workload, and poor facilities in schools. Our study on the current practice of teaching among secondary school science teachers confirmed that these long-standing issues still exist. We used interviews, observations, and documents to frame the current practice of teaching as well as investigating the reasons of using those teaching practices. These old issues along with the lacking in integrated STEM training for in-service science teachers must be solved to better implement the STEM integration. Our study suggested that Malaysian schools may need to have a better resource sharing model among stakeholders in STEM education like scholars, parents, companies and industries, colleges and universities, federal and state governments, and civil societies. We named it "STEM Education Community". This community needs to be well coordinated and to share each member's expertise, financial resources, learning materials, feedbacks, human resource, and facilities. We hope that this type of new working model can be realized in Malaysia as well as in other countries that may be facing the common issues in STEM education.

[27O3E-5] STEM in Early Childhood Education: Findings from a Canadian Case Study (*A0330*)

Todd M. Milford*[+] and Christine D. Tippett

University of Victoria and University of Ottawa, Canada

ABSTRACT Problem statement: Research in STEM education is typically focused at the secondary and post-secondary levels with limited attention paid to the elementary level. However, even at the Pre-Kindergarten (Pre-K) level, some teachers are including STEM activities in their curriculum. Therefore, STEM in early childhood education is an area that warrants a closer examination. Purpose: Our aim was to explore whether STEM might be appropriately incorporated in early childhood education by examining data collected from multiple stakeholder groups (educators, students, parents, and administrators). Our role in this exploratory study was to observe activities that were planned and implemented by the educators; therefore, we had no input on activity design. Our research question was How do data collected from multiple stakeholders inform our understanding of early childhood STEM education?

Methods: Our mixed methods case study was situated in a Pre-K classroom (ages 4-5) at a small private girls' school in western Canada. Participants included 2 Pre-K teachers, 14 students, 11 parents of those students, and 2 administrators. Tools developed for the study included a classroom observation protocol (COP) and a parent questionnaire. Both qualitative and quantitative data were collected through Pre-K teacher interviews, classroom observations, student work samples, student focus groups, the parent questionnaire, and administrator writing prompts. Educator interviews were transcribed and iteratively coded for themes. Field notes from classroom observation were analyzed using the COP. Student work samples and transcripts from the student focus groups were examined for evidence of conceptual understanding of STEM activities. Parent questionnaire responses were analyzed quantitatively (closed questions) to reveal central tendencies and qualitatively (open-ended questions) to highlight themes. Administrators' written responses were analyzed for themes using an open coding process.

Findings: Results of the analysis of data collected from and about educators, students, parents, and administrators provide a snapshot of STEM education in a particular Pre-K setting. We developed four inferences: (i) teachers believe that STEM provides a valuable framework for Pre-K classroom activities; (ii) students actively engage in STEM activities; (iii) parents respond positively to STEM in their child's Pre-K classroom; and (iv) administrators are enthusiastic about the educational affordances of STEM.

Conclusions and Implications: The data from all stakeholder groups suggests that STEM can be an appropriate component of early childhood education. A STEM approach can provide meaningful integrated learning opportunities for young children. Children can be highly engaged in a range of skills and actions that are likely to promote STEM learning (questioning, play, process skills, and scientific and engineering practices). STEM in early childhood education is an area that deserves more attention; however, further research is certainly warranted.

[27O3E-6] Needs for STEAM Education Models to Support Science Teachers (*A0210*)

Hyunju Lee
Ewha Womans University, Korea

ABSTRACT Over the past several years, we have been implementing diverse types of professional development programs for elementary and secondary science teachers to promote STEAM (Science, Technology, Engineering, Arts, and Mathematics) education in South Korea. Some satisfactory results of the PD program have been reported. However, science teachers still raise the following two questions. One is what we should pursue and aim to achieve through the STEAM education. When designing classes, we usually clarify learning goals, decide sequence of the contents driven by the goals, and evaluate the learning outcomes on the basis of the goals. However, the current suggested goals of the STEAM education (e.g. creative and convergent thinking, feeling of accomplishment, etc.) are too broad and vague for teachers to actualize in classes. And the other is a more methodological question: how and to what extent should we make connections among diverse disciplines when creating STEAM lessons? In this presentation, therefore, I would like to introduce one STEAM education model which can play a role as a guideline for science educators to design and execute STEAM ideas in schools. This model emphasizes more operational definitions of the goals in the form of key knowledge, key competencies, and key characters and values. In addition, it suggests three dimensions of convergence to consider when developing STEAM lessons: 1) unit of convergence (i.e. concept/skills, problem/phenomenon, activity), 2) degree of convergence (i.e. multi-disciplinary, inter-disciplinary, extra-disciplinary), and 3) context of convergence (i.e. personal, societal, global).

<3F> Curriculum/Teaching Materials

Chairs: Maurice M.W. Cheng (The University of Hong Kong), Jia-Ying Lin (National Taiwan Normal University)

[27O3F-1] How Students React to the Analogies from Textbooks (PEP) in China (*A0304*)

Xinyun Cheng, Wei Wang, Jingyu Xiang, and Xiaoxiao Fu
Sichuan Normal University, China Mainland

ABSTRACT In everyday life we learn so many things by comparing and contrasting. The use of analogies and metaphors is important in science itself and their use in teaching science seems a natural extension. As one part of metaphor, analogy refers to the understanding and experiencing of something unknown, and something that is not completely understood or unidentified in term of something familiar in our learning process. Recently, it has been proved that analogy not only help students' concept construction, and high level thinking abilities ' improvement, which include reasoning, transferring, creativity and so on, but is a good tool for teachers to access and predict the learning. So analogy plays an important role in the field of science education. As a sophisticated knowledge's vector for teaching used in formal education, textbooks are not only the organizing means of knowledge elements, but also the carrier of methods and learning process. As one form of language representation, analogy in textbook is aim to help students construct knowledge and improve abilities. So this study focuses on arguing the following issues: (1) How the analogies are represented from textbooks (People's Education Press, PEP) in China? (2) How the students react to the analogy from textbooks (PEP) in China? First of all, analogies are identified and classified from textbooks (PEP) based on category framework codon system, which is developed by Ruth V. Curtis etc. The result indicates that there are 52 analogies from high school biology textbooks (PEP), 77.78 % of the analogs and targets share functional attributes, the rest share structural attributes; 81.48% of the analogs presentation format are verbal, the rest are pictorial-verbal; 72.22% target concepts are abstract cognitive level and have concrete analog, the rest target concepts are concrete; 75.93% analogies are presented as embedded activators, the rest are presented as advance organizers or in the margin of the textbooks; 51.85% analogies are explained richly, which means textbooks have some discussion of shared analog-target attributes stated, while 44.44% analogies are simple, which means no discussion of shared attributes, and the rest are extended to explain; 48.15% analogs are explained before the topic was represented, the rest have no additional explanation of analogs; only 5.56% analogies explain the difference between analog and target concepts, the rest have not. Different quantitative proportion of each analogy type has different meaning. Then, 125 high school students are surveyed how they react to the analogies about the cell theme. Analyzing the relationship between the students' familiarity to analogy and their improvement by spearman correlation coefficient, whose sig. value is 0.002(＜0.01). This shows that the helpfulness of students about analogy is the impact of familiarity. However, students often focus on the surface function of analogy, such as visualization or interestingness , but not on the expansibility, which is related to having more question by analogy, or creativeness, which is associated with creating more new similar analogies, so the sig. values between helpfulness and expansibility, helpfulness and creativeness are both larger than 0.05. By qualitative analysis of students' abilities of expansibility and creativity, this study found many questions students want to know and many generative analogies made by students after learning the cell theme analogies. Such as cell is like a factory and organelles are like departments, many students want to know if the cell is repaired as factory or if the number of organelles is changed when the cell's demands change as factory's adjustment. And some students regard cell as a class, student union and so on. Many implications are got from analyzing the students' answers

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[27O3F-2] A Comparison of the Effectiveness of Animation and Augmented Reality in Learning the Concepts of DNA (*A0356*)

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ABSTRACT DNA is a fundamental and crucial concept to the genetics. Teaching and learning DNA is an important issue for science education. However, because the structure of DNA is complex and invisible, students cannot visualize the microstructure correctly and often fail to learn the

concept of DNA. Many studies demonstrated that animation and augmented reality can help students learn science. Animation is powerful technology tool when representing dynamic processes; augmented reality is a technology tool supplementing the real world with digital information and media. Both animation and augmented reality can help student understand the microstructure, but few studies compared the effectiveness of animation with augmented reality. The aim of this study is to investigate the different impact between animation and augmented reality on the learning of the concept of DNA. 54 seventh graders participated in this study, 28 students served as the DNA augmented reality group, the remaining 26 students served as the DNA animation group. In the DNA animation group, students observed a DNA animation in the class; in the DNA augmented reality group, students used a tablet to observe an augmented reality DNA model in the class. Data were collected by paper-and-pencil test, questionnaire and interview. Students' achievement of the concept of DNA were measured by pre- and post-tests. A one-way analysis of covariance (ANCOVA) was adopted to compare the effectiveness between DNA animation group and DNA augmented reality group, in which students' pre-test scores were used as the covariate. Through the data analysis, we concluded that (a) Both DNA augmented reality learning system and DNA Animation learning system can promote students' achievement; (b) DNA augmented reality learning system is more effective to low-achievement students than high-achievement students; (c) DNA Animation learning system is more effective to high-achievement students than low-achievement students. This study provided a new strategy to teach the concept of the DNA.

[27O3F-3] Developing Understanding of Image Formation through the Luminous Ray Model Mediated by Virtual Simulation and Physical Experimentation (*A0388*)

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ABSTRACT Previous research in physics education has shown that students hold a wealth of misconceptions about image formation. The ray model is usually applied to explain optical phenomena involving light propagation through an optical system and the formation of an image. However, students have difficulties in understanding the image formation in some cases because students thought the ray model only represents special light rays. In the present study, we replaced the traditional ray model with the luminous ray model (LRM) to help students understand image formation by lens and mirrors. In addition, the positive impact of virtual simulation (VS) and physical experimentation (PE) in learning process has been documented over the past few decades. Although substantial studies have been performed on the comparison between VS and PE, few studies of image formation have been done to date. The purposes of this study were to investigate high school students' conceptual change in learning image formation through the luminous ray model and explore which of these two modes of manipulations is more beneficial in different optical concepts. Four classes of tenth graders (total N=140) were randomly assigned to four types of learning modules, LRM (n=33), LRM+VS (n=37), LRM+PE (n=36) and T (The traditional group, n=34). Students' conceptual understanding of image formation was measured by two-tier conceptual pre- and post-tests. A one-way analysis of covariance (ANCOVA) was adopted to compare the effects of four types of learning modules, and students' pre-test scores were used as the covariate. On the whole, we found that the three experimental groups had significantly higher posttest scores than the traditional group, but there was no difference among the three groups. This finding implies that the LRM plays a vital role in improving students' conceptual understanding. A further analysis showed that LRM+VS was more beneficial than the other modules regarding the misconception that the object laying on the horizontal central axis couldn't form image or form in the wrong direction. On the other hand, LRM+PE was more beneficial than the other modules regarding the misconception that the real image couldn't be seen without a screen. It not only implied that VS and PE carry a number of different affordances, but also indicated that relatively simplified and idealized models inhibit students' ability to transfer the basic principles to the real world problems. These findings will help science teachers develop an instructional module to facilitate students' learning in image formation.

[27O3F-4] The Application of Universal Design for Learning in Elementary School Science Class: Focused on the Level Control for Visually-handicapped Elementary Students (*A0489*)

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ABSTRACT Many science educator point out that the education system not to respond sensitively to individual characters of students in school would make them frustrated and have low achievement in their learning. Based on the problem for education, recently, educator and scholars are emphasizing the responsibility for both of handicapped student and non-handicapped student to promote their educational achievement. For solving this educational problem, Universal Design for Learning(UDL) is getting more important for students with various abilities in learning to access easily curriculum and succeed in learning. Universal Design for Learning is getting more important to integrate handicap student and non handicap student in education in terms of the objectives of modern science education oriented to foster the scientific literacy of all students and educate every citizen. Universal Design for Learning reflected educational needs of handicap student and non handicap student is able to make students access easily to curriculum, whereas science class in reality is consist of principle and experiment lesson, particularly, the experiment lesson can't be implemented effectively for integrated education. Especially, visually handicap students have difficult to use the experiment equipment designed for non handicap student. Therefore, in this study, we developed two experiment equipments, "spring experiment equipment and balance for the visually handicapped", analyzing the elementary science textbook in Korean and USA curriculum. Then these experiment equipments was applied to visually handicap elementary school students who were in Busan School of the Blind in Korea in order to

check applicability of the equipments. Participants were seven students with a simple visual handicap from among students in the 3th to 6th grades for the experiment and counseling. The results of this study in the school show us positive applicability to apply spring experiment equipment and balance for the visually handicapped to science class in reality. Also, for helping non handicap student with understanding visually handicap student, the equipment was applied to elementary science class as scientific experiential activities for students with a sight disability. After taking part in the experiential science activities for students with a sight disability, non handicap students showed positive responses towards visually handicap.

[27O3F-5] Strategies for Introducing the Particle View of Matters: Cognitive Conflicts, Practical Activities, Multiple Representations and Assessment for Learning (*A0543*)

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ABSTRACT This presentation reports teaching strategies that aimed to introduce to Grade 7 students for their very first time the particulate nature of matter. The project was a collaboration between school teachers and university science education researchers. This presentation aims to be very focused, to the extent that it describes the teaching strategies of a 40-minute lesson that were adopted by school teachers participated in this project. The lesson was an orchestration of (a) practical work, (b) the use of cognitive conflicts, (c) the use of students' generated multiple representations, and (d) with a strong flavour of assessment of learning (AfL). The particulate view of matter was introduced to students as a resolution to a puzzling phenomenon, namely, the volume contraction of mixing water and alcohol. Key components of the lesson were as follows: (1) Students were asked to mix 50ml of alcohol and 50ml of water, and to record the volume of the mixture. They were also asked to record the mass of the alcohol, the water and the mixture. The activity aimed to create a cognitive conflict among students, who were likely to expect a conservation of volume. Class discussion followed. It aims to solicit views from students about the reason for the volume contraction (AfL). At this point, the teacher would not offer the explanation, and left the phenomenon as a puzzle. (2) The teacher suggested that in order to solve the puzzle, the class would do another activity. This activity involved mixing 50ml of sagos (very tiny tapioca) and 50ml of soya beans. The students were expected to measure the volume of the mixture after a thorough mixing. (3) Students were asked to explain their findings, i.e., volume contraction of the mixture, by using words and diagrams (AfL by student-generated multiple representations). The teacher would then do a roundup session that examined students' explanations. (4) Using a diagram, the teacher introduced to students how water might be like at a submicro level, i.e., it's made of a vast number of water particles that were too small to be seen by naked eyes or any microscopes. Then, students were asked to use words to describe the spatial arrangement of water particles in the diagram. It was a means where the teacher could assess students' interpretation of the diagram (AfL, by multiple representations). Then, the teacher introduced to students the diagram representing alcohol (with alcohol particles having a larger size than that of water particles). (5) The teacher pointed out that the volume contraction of water/alcohol mixture could be likened to that of sagos/soya beans. Students were asked to explain the volume contraction introduced in (1) by the use of both words and diagrams. This was another AfL opportunity where the teacher could be informed of students' learning from the metaphor. The presentation will be supplemented by classroom videos. Further comments about the teaching strategies and their limitations will be made in the light of the classroom practice as demonstrated in the videos.

[27O3F-6] Enhancing Students' Learning Achievement and Argumentation Ability by Hands-on Experiment Integrated with Argumentation Procedure (*A0058*)

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ABSTRACT Nowadays, the ability of argumentation is very important to every new citizen. However, most of the elementary school science textbooks in Taiwan are lack of systematic content for argumentation training. Owing to this fact, since 2014, we started to design a series of hands-on experiments which were integrated with argumentation training process for 4th- to 6th-grade students. The argumentation procedure (claim, data, warrant, backing, and rebuttal) was integrated into the working sheets of the experiments. The teachers who used these teaching materials guided the students to finish the worksheets. This research focus on whether the 5th-grade teaching material, "thermal convection", is helpful to bring up the learning achievement and argumentation ability of the low-science-learning achievement students. In addition, we are going to find out which science-learning achievement level performs the best by using this teaching material. We used water valve, silicone, and two plastic cups for making experimental setup of thermal convection. When the valve was opened, one could see the hot water (red) flowing up and the cold water (blue) flowing down. 72 5th-grade students learned "thermal convection" via this teaching material. By doing the working sheets after the experiment, students could experience the argumentation procedure. The instruments of this study are learning achievement test (KR20 = 0.70) and argumentation ability test (KR21 = 0.80). We made a comparison by t-test between the pre- and post-test. The result shows that the learning achievements of all the science-learning achievement levels are significantly improved. However, only the low-science-learning achievement group has a significant improvement in the argumentation ability test. We can conclude that the low-science-learning achievement students performed the best after learning "thermal convection" through this teaching material which we designed. We are going to make a detail report in this oral presentation.

<3G> Curriculum/Assessment/Policy

Chairs: Atsushi Yoshida (Nagoya Gakuin University), Yau Yuen Yeung (The Education University of Hong Kong)

[27O3G-1] The Analysis of the Meaning of Science Core Competency Education (SCE) in the Next Science Curriculum (*A0339*)

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ABSTRACT The purpose of this study was to analyze the elements of the Science core Competency through the conceptual definition in Cross-Curricular and Science core Competency Education. To achieve the research purpose, we refer to the former research, that was selected 47 articles and reports about concept of core competency using network key words analysis. Also we selected 21 articles and reports about the elements of the Cross-curricular core Competency and the Science core Competency. The results of the study were as follows: First, we found out 91 key words and 479 links. And in the result of the text frequency analysis in Cross-curricular core Competency, the key words appeared in order of 'Social interaction skill', 'Learning skill', 'Personal skill', 'Communication skill' and 'Using ICT skills and tools'. Also we found out 78 keywords and 387 links in Science core Competency. The keywords appeared in order of 'inquiry skills', 'scientific communication skills', 'scientific thinking', 'knowledge' and 'creative thinking'. Second, In domestic research, a network built up with core hubs such as 'scientific thinking', 'scientific communication skills' and 'scientific emotions'. On the other hand, 'inquiry skills', 'scientific communication skills' and 'knowledge' comprised key elements of Science core Competency in the overseas research. Third, the 2015 revised science proposal was needed to reflect 'knowledge', 'basic inquiry process skills', 'scientific attitudes and emotions' and to reestablish the structure. Based on these results, we suggested that the introduction of the Science core Competency Education(SCE) should be implemented according to the connection with Cross-curricular core Competency(CcC).

[27O3G-2] What Does "Lesson Study" Carry for Science Education Research? (*A0119*)

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ABSTRACT This presentation will focus on the role and meanings of "lesson study". Lesson study has not been widely used by science education researchers, as it is complicated to study the already complicated matter of lesson study. Lesson study is teacher development through active critiquing of one's teaching in conjunction with a mentor or master teacher. Because lesson study is a deeply involved process, the researcher of lesson study must be doubly prepared to be in sync with planning of the lesson with the related lesson study personnel in terms of objective, materials, lesson plan, assessment, and so on. A further complication is that lesson plans do not normally go exactly as planned—various factors in the course of a lesson affect a lesson one way or the other. Teachers and researcher have to define the objective, materials, lesson plan and assessment way before practice. In practice, teachers do it under lesson plans, however, lesson is affected variable incidents in a class. There is no same class activities by one teacher who develop teaching materials and lesson plan, because of teachers-students' interactions. The activities of teacher and students should be analyzed and found out some points to improve cooperating with school teacher and educators. Science education researches should be developed both theoretically and practically, to improve science curriculum and teaching practice. Some science researchers should want to improve science lessons for school teachers and pre- and in-service teacher education. Looking classrooms will give science educators how difference between ideal and practice. We, Atsushi Yoshida, Shoju Tonishi, Japan, Kong Young Tae, Korea, Mei-Yu Chang, Taiwan and Alice Siu Ling Wong, Hon Kong, have been developed lesson study both elementary and lower secondary science. I would like to summarize the results and implementations through three years projects. Especially, qualitative analysis and general impressions will be comparing Japan, Korea, Taiwan and Hong Kong science lessons.

[27O3G-3] The Cultivation of Outstanding Chemistry Teachers: Teaching Strategy Design and the Characterization of Such Design (*A0301*)

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ABSTRACT Teaching goals is the beginning and ending of classroom teaching, while teaching process is the path and method from beginning to ending. Teaching strategy which is always among the teaching goals and the teaching activity process previously forms a bridge for the coupling of both, so its importance is self-evident in the whole course instruction design elements which contain teaching task, students present situation, teaching conditions, teaching goals, teaching strategy, teaching process, teaching measurement and evaluation. However, we found in many investigates, there are a short of teaching strategy in the conventional instruction design, two elements separation between the teaching goals and teaching process design, and instruction design being late of the actual classroom teaching activities. Because teachers find it is difficult to search accurate words to convey the knowledge on the concept of the hierarchy and they are unknown which pattern is perfect to express. To improve it, we developed a way of using visual information and technology to express the teaching strategy, according to the characteristics of explicit knowledge (the text content) and tacit knowledge (the teaching thoughts) in instruction design, then teaching strategy design is visualized by the computer software or the hand drawing system. On the basis of the "Concept Map and Mind Map", we illustrated the method and procedure by Hand-drawing teaching strategy with specific instruction design as an example, hoping the teaching goal design intention can be converted into a more detailed teaching activities process design in order to achieve the effective integration of teaching goals, teaching process, measurement and evaluation.

[27O3G-4] PISA Science Framework Driven Analysis of Chinese National Primary Science Curriculum (*A0574*)

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ABSTRACT Scientific literacy has been descried as a main goal in science education since 1950s, which firstly favored in western countries. At the end of 2000s, China started its educational reform. In 2001 China published the first National Primary Science Curriculum (Standard), which declared for cultivating scientific literacy and promoting scientific inquiry teaching and learning. The Chinese National Curriculum is an underlying skeleton directing the science teaching and learning. However, few research has analyzed the level of scientific literacy focus or preference in the Curriculum from an international perspective. Thus this research aims to analyze the Chinese National Primary Science Curriculum through deductive content analysis. Our analysis framework is based on PISA science framework 2015. We chose this framework as a start for three reasons. Firstly, PISA science framework constructed on scientific literacy, which is consistent with the goal of Chinese Curriculum but with an international view. Secondly, PISA framework was created for science assessment, which indicates it has a nice concept structure. Moreover, it is developed for about 15 years by a number of researchers. Thirdly, although PISA assessment is originally for 15-year-old, the framework is a concept framework focusing on scientific literacy. It demonstrates only degree differences of the requirements between primary school students and middle school students, which will not affect the structure and concepts for analysis. Our analysis went through defining categories based on PISA science framework, pilot testing of categories, revision of categories and coding rules, formative check of reliability, final working through the texts, and interpretation of the results. The first author translated the Chinese curriculum into English. Then the first and second author coded around 20% of the curriculum independently. Three authors discussed the pilot coding results and revised the analysis framework and coding rules together. After revision, the sample of text was analyzed again independently by first and second author. Finally, the first author analyzed the whole text twice. Four main categories and several subcategories have been investigated: (1) 'Scientific competences' include for example, 'explain phenomena scientifically' four competences; (2) 'Scientific knowledge' consists of content knowledge, procedural knowledge and epistemic knowledge; (3) 'Scientific attitudes' include such as 'interest in science' and 'environmental awareness'; (4) Contexts in science education. We found that the curriculum is internationalized consistent with PISA science framework and fits with the education goals of scientific literacy. Competences (25%) and knowledge (35%) are almost equally highlighted, which indicates changes from memorizing centered education to competence development emphasis. Admittedly content knowledge is the majority of Scientific Knowledge category, epistemic knowledge (19% of this category) is underlined as well. Moreover, the curriculum shows preference in relating context (30%) with science education, especially environmental and natural resources issues. Attitudes relating to interest in science, critical competences and environmental awareness are most underlined. The results also implies the curriculum outlined numerous requirements at primary level, which could be difficult achieved in practice.

[27O3G-5] Development of a New Dual Major Science Teacher Education Programme in Hong Kong: Approaches and Implications for STEM Education (*A0604*)

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ABSTRACT In response to the Hong Kong government's call for renewing and enriching "the curricula and learning activities of Science, Technology and Mathematics, and enhance the training of teachers, thereby allowing primary and secondary students to fully unleash their potential in innovation", the author collaborated with a team of science teacher educators and scientists to develop a new dual major science teacher education programme called Bachelor of Education in Science (BEd(Science)) which prepares competent graduates for teaching two senior secondary science subjects (physics, chemistry or biology) as well as the junior secondary science. Compared with the conventional Bachelor of Science (BSc) programme offered by many other universities, our BEd(Science) has the special programme features of not only offering three kinds of dual majors (physics + chemistry/chemistry + biology/biology + physics) but also deliberately integrating subject knowledge with pedagogical content knowledge in many science courses, practising pedagogy in field experience (to be conducted in school environment) and delivering the programme by a teaching team composed of both scientists and science educators. Apart from five foundation courses in science and science education, there are nine advanced science subject courses plus a subject-specific pedagogy course in each chosen major. Besides, our design of the curriculum content of the BEd(Science) programme is based on a detailed examination of the local school science curricula so that it is ensured to cover all the subject knowledge necessary for the effective teaching of the corresponding school science subject. Hence, those advanced science courses or topics such as advanced quantum mechanics, which are usually required for specific scientific research but are not relevant nor required for the teaching of secondary science, will be replaced by other educational courses or topics which could effectively help school pupils remove their common misconception in science learning or get more in-depth understanding of the topics etc. Comments and feedback on our programme structure and course outlines as received from various internal quality assurance bodies and external review by three overseas scholars will be discussed together with the detailed rationales, framework, structure and the modifications of the programme as well as the foreseeable implications for STEM education in Hong Kong and her neighbouring regions.

[27O3H-1] Explore the Effectiveness of Science Remedial Teaching for Fourth Grade Students via Video and Plickers (*A0605*)

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ABSTRACT Since TV was invented, the video tutorials have been developed for a long time. In recent years, the full high-definition resolution videos can be provide. Although the video tutorial cannot replace the classroom teaching, but it maybe can used science remedial teaching. By showing the high quality scientific experiments video to learners, a learning experience similar to live learning sessions can be created. Beside, interactive response system can enhance students' motivation to participate the learning process, but the equipment is too expensive for primary schools. Plickers can solve this problem. We use the quiz – teaching videos strategy in designing the scientific remedial teaching videos. If necessary, we also offer 3D experimental film. We edit the related news videos of the scientific topics to enhance student motivation. We also use the Plickers to collect the individual responses of students in the teaching process. In the study, we invited 20 fourth grade students to participate the remedial science teaching. Each student's science test score was the last 25% in their own original class. Before participated the remedial teaching, the average of T-score was 35.80. After participated the remedial teaching, the average of T-score was 42.84. The results analysis indicated a significant difference ($t=3.34$, $p < .003$). The results shows that scientific remedial teaching can promote the science achievement of low-performance students. It can promote the students' learning motivation. This method can simplify the remedial teaching procedure, and provide more learning opportunities for students of low achievement.

[27O3H-2] Development of a Self-made and Self-measuring Arduino-based Measuring Device, Data Logger (*A0175*)

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ABSTRACT Science teachers had been realized that the science classes needed to involve student lab activities as well as lectures. However, the current situation of science classes is not so much improved. In order for students to engage in lab activities much more actively, it would be effective, we believe, that individual students could hold their own measuring devices at hand for the possible use of their planned experiments. Also, learning of fundamentals of micro-computer is promising since voices of 'ICT in education' and 'IoT (internet of things) in industry' have been prevailing. In this study, we proposed an Arduino compatible measuring device, which was small, cheap and easily made by high school students, for a possible use not only as a simple measuring instrument, but also as a data logger. This device would promote individual students (1) to acquire fundamental knowledge of micro computing by self-making, (2) to perform measurement experiments within the period of lab classes by utilizing their own devices, and (3) to challenge longitudinal measurement of a set of data by using the function of data logging. The device would also enable students to challenge experiments or measurements on daily natural phenomena, guided by their own interests beyond the formal class settings.

[27O3H-3] Enhancing Science Learning with BYOD (Bring Your Own Device) in a Primary School in Hong Kong (*A0277*)

Yanjie Song*+ and Daner Sun
The Education University of Hong Kong, Hong Kong

ABSTRACT This chapter reports on a one-year study, investigating how students in a primary school in Hong Kong advanced their content knowledge of science in a seamless inquiry-based learning environment leveraged by BYOD (Bring Your Own Device), taking the topic of "Flowers and Seeds" in the Biodiversity learning unit as an example. One teacher and 28 Grade 6 students were involved in this study. The students' inquiry learning activities were documented using various apps. Qualitative data including pre-and post-domain tests, class observations, student artifacts, online postings and field notes were collected and analysed to examine students' learning. The findings suggest that effective use of apps such as Skitch, Edmodo and Evernote with BYOD using an inquiry-based learning approach, could help younger students advance their knowledge in science, develop personalised learning skills and gain a better sense of ownership in science learning. In addition, the results indicate that tracing individual and group inquiry activities in multiple spaces can make the learning process and outcomes visible that may inform teachers and learners of their enhanced educational practices. [Draft]

[27O3H-4] The Production of the Liquid Shooter Program which Fuses Science and Art, using Bitbrick Sensors (*A0593*)

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ABSTRACT The purpose of the production of this program is to provide a multidisciplinary program that its user can understand the scientific principles of the chemical reactions included in the program, and can admire the beautiful media art created by the program, therefore letting the user experience science and art at the same time. The Liquid Shooter program consists of four parts. They are the main character and its manipulator, the calculator, the position selector of the liquid particle, and the power gauge. The main character is the most essential part of the Liquid Shooter program, enabling the user to control the variables of the program such as the angle of the liquid when sprayed, the quantity of the liquid, and the velocity of the liquid particles. The calculatior works like a central processing unit, as it calculates and decides the initial velocity and the course of the particle guides. After this process, the calculator sends the position of the particles to the position selector. The position selector works as an output device, since it forms the liquid particles on the positions sent by the calculator, and makes the liquid particles slide down on the screen. The power gauge represents the variation of the timer, which manipulates the velocity of the liquid particles. The power gauge increases being proportional to the number of the timer. We modificated the program to a two-user program so two users can employ the program at

the same time. Additionally, we upgraded the program from a passive method using input devices of a computer such as a mouse, to an active method which the user moves his or her body briskly. The Liquid Shooter program gives the users an opportunity to enjoy science and art simultaneously by showing chemical reaction processes through media art. We adjusted accurate results for each chemical reactions, thus students would be able to understand the basic concepts of chemical reaction easily, and would be impressed by the media art created through the reactions. Also, anyone who uses the program can do creative activities by developing various kinds of chemical reactions on their own, not using combinations formed by others. In addition, to allow users to use the Liquid Shooter in relatively longer distances, we will use a human body perception sensor with the program.

[27O3H-5] A Consideration of Modelling Evaluation with Referring Functions of ICTs: Modelling Workshops Using Graphing Calculator with LEGO®MINDSTORMS®EV3 (*A0527*)

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ABSTRACT We come up with modelling as an approach for linking mathematics to other subjects. In addition we hope that modelling can be applied to STEM education in Japan (Matsuzaki, 2015). So we have planned and implemented modelling workshops by experimental and observation type approach on the premise of using ICTs (Tsukahara & Matsuzaki, 2014a, 2015a). In this paper we report modelling workshops on the premise of using ICTs (graphing calculator, sensors, and LEGO®MINDSTORMS®EV3). We planned modelling workshops based on a modelling cycle added computer model (Greefrath, 2011; Greefrath et al., 2011), and implemented modelling workshops for university students in Japan (Tsukahara, 2015) and for upper secondary students and graduate students in Turkey (Matsuzaki et al., 2015; Matsuzaki & Tsukahara, 2016; Tsukahara & Matsuzaki, 2014b). We focus on functions of the ICTs, and classify their responses for modelling evaluation problem (Tsukahara & Matsuzaki, 2015c). Graphing calculator can display scatter plot based on collected data transferred via PC. LEGO®MINDSTORMS®EV3 connected to sensors can collect data of distances/angles as time goes by. So We specify data logging function of LEGO®MINDSTORMS®EV3 and trace function of graphing calculator. Before and after each workshop we use developed modelling evaluation problems (Tsukahara & Matsuzaki, 2015b), and identify data logging function of distance/angle for modelling and trace function for modelling (Tsukahara & Matsuzaki, 2015d). In a case study we confirm the identified functions for modelling of eleven university (engineering) students (ten undergraduate students and one graduate student) in Japan. We can find extra function for modelling which is differ from the identified functions. For example, changing initial conditions mean change from real situation to situation model, and switching sensors on/off mean characteristics of digital tools in case of controls of sensors or mathematical models which is non-continuous graphs influenced by computer model. Developed modelling evaluation problems are not become with referring A-D scatter plot which is located in computer result. It is said that trace function for modelling is able to handle computer model by experimental and observation type approach using graphing calculator with LEGO®MINDSTORMS®EV3.

<3I> Integrated (SSI, EE, ESD)

Chairs: Hye-Eun Chu (Macquarie University), Nina Christenson (Karlstad University)

[27O3I-1] Using ePCK as a Framework for Examining Factors that Influence on Elementary Teachers' Perceptions in a Graduate Level Interdisciplinary Environmental Education Program (*A0082*)

Young Joo Lee[1], Hye Eun Chu[2], and Sonya N. Martin[1]

1. Seoul National University, Korea and 2. Macquarie University, Australia

ABSTRACT The purpose of this study was to examine teachers' perceptions about their own Environmental Pedagogical Content Knowledge (ePCK) and analyze factors that influence on teachers' ePCK. Specifically, this research was situated in the context of a graduate level Interdisciplinary Environmental Education (GIEE) program at a prominent university in Korea that serves a large population of elementary teachers who play a deciding role in determining what and how to teach their classes with regards to Environmental Education (EE). Based on prior-research study on PCK and literature studies of teaching practices in EE, the Exploring Elementary School Teachers' ePCK (EEST:ePCK) questionnaire was designed to measure teachers' generalized PCK in the context of EE. The EEST:ePCK used a four-point Likert scale consisted of seven sub-knowledge areas with item statements about Knowledge of Subject Matter, Knowledge of Curriculum, Knowledge of Learner, Knowledge of Instructional Strategies, Knowledge of Environmental Context, Knowledge of Educational Goal, and Knowledge of Evaluation. Demographic variables, teachers' experience of participation in EE programs, and information of school EE programs were also asked. By comparing responses of teachers who have completed the GIEE program (treatment group) and teachers who have not completed the program (control group), the impact of the GIEE program on teachers' ePCK was explored. A total of 173 teachers (treatment group N=51; control group N=122) participated in the survey using an electronic survey system called Survey Monkey. A total of 130 of the teachers' responses (treatment N=44; control N=86) were included in the final analysis. About 70% of the teachers who participated in the survey were female (treatment group, N=33; control group, N=11), which is representative of the percentage of elementary teachers reported to be female in Korean public schools. Teachers in both groups tend to teach a relatively large number of students in their class (24-42=63.8%) and approximately 50% in each group reported they have been teaching for less than ten years. Finally, a majority of teacher participants in both groups indicated that the schools in which they work tend to implement environmental education activities. The results of this study indicate that the majority of the teachers in the treatment group evaluate themselves to have relatively high levels of ePCK compared to the control group. However, teacher responses on the subdomains Knowledge of Instructional Strategies and Knowledge of Evaluation reveal very little differences between the two groups suggesting

that there is room for improvement in the design of the GIEE program. In addition, some aspects of a teachers' background like the number of years of teaching experience may impact on teachers' perceptions of ePCK but the GIEE program can help to supplement the gap in knowledge experienced between beginning and veteran teachers. Finding from this research indicates that teacher education programs, such as the GIEE, can positively influence teachers' perception of ePCK by enhancing teachers' professionalization related to various forms of knowledge about EE. However, in order for effective EE instructional practices to be implemented in teachers' classrooms, it suggests teacher education programs need to focus with more attention on developing teachers' ability to apply the knowledge learned in the courses into real classroom settings. By using an ePCK framework, curriculum designers and teacher educators might be able to more effectively target aspects of their programs that can complement the implementation level of EE topics in elementary school classrooms.

[27O3I-2] Examining the Effectiveness of Using Children's Picture Books in an English as Foreign Language (EFL) Classroom to Teach Education for Sustainable Development (ESD) Concepts to Elementary School Students (*A0440*)

Ga-Young Song[1]*, Hye-Eun Chu[2], and Sonya N. Martin[1]*+

1. Seoul National University, Korea and 2. Macquarie University, Australia

ABSTRACT In Korea, elementary age children are required to learn English as a foreign language (EFL) and to learn about Education for Sustainable Development (ESD). However, because ESD is an elective education program, studies show elementary students fail to engage with this material. To expand opportunities for elementary students to learn ESD concepts, we created an ESD related curriculum using English language picture books that can be used as EFL teaching materials in the elementary school. Because teachers do not generally have expertise in the ESD field, we developed an evaluation rubric to help choose picture books that could be used to teach sustainability concepts and that were a quality literature resource that could help develop English language learning. In this presentation, we describe the process to develop our tool, discuss our use of the tool to evaluate ESD related picture books, and offer a brief account of findings from a pilot project using picture books to teach ESD lessons in an EFL elementary classroom in Korea. We reviewed literature about how to evaluate children's picture books. We also examined Korea's national content standards to identify important concepts and themes in ESD education, which reflect ESD concepts recommended for elementary learners in other educational contexts. Finally, we used the Sheltered Instruction Observation Protocol (SIOP) model to identify key concepts and strategies needed to promote positive language learning. The evaluation criteria included three key scales and 6 total subscales: 1) characteristics of quality picture books (2 subscales), 2) ESD related themes and concepts (2 subscales), and 3) EFL related themes and concepts (2 subscales). We describe our validation process for developing the evaluation rubric, which included literature review and interviewing eight experts in the areas of ESD and EFL to help us revise and strengthen out tool. We describe the results of our evaluation of picture books as examples of how to use the criteria and using these books, we designed and implemented a short pilot project to help us teach some lessons using evaluated books to explore their impact on EFL students' language and ESD content learning. Overall, we found that few books are high in quality in all three categories, which means that teachers will need to use multiple sources in their lesson development and selectively introduce parts of books to maximize ESD learning opportunities. In addition, we found that using ESD related stories promoted more opportunities for authentic and meaningful discussions in the EFL class. Students learned about ESD concepts while enhancing their English language learning. Students genuinely enjoyed learning with the picture books, which positively impacted on their participation and engagement in the lesson and also promoted more and different forms of language construction – such as listening and reading comprehension. The students also engaged in more talk in whole class and small group activities when using the simple text and illustrations as a resource for discussing more complex issues related to ESD concepts. We conclude with implications for teacher education and classroom practice and we suggest recommendations for future research.

[27O3I-3] Exploring the Influence of Korean and Australian Students' Science Capital on Conceptual Understanding and Modeling Processes (*A0439*)

Hyung Kyu Ku[1], Hey-Eun Chu[2], Seung-urn Choe[1], and Sonya Martin[1]

1. Seoul National University, Korea and 2. Macquarie University, Australia

ABSTRACT This study is part of a larger cross-cultural arts-integrated curriculum project using STEAM (Science, Technology, Engineering, Arts and Mathematics) activities in grades 3-6 to improve science content learning for Australian and Korean students while also increasing these students' awareness of cultural differences and similarities in each country. Data was collected over a 4-week period from 120 Korean and Australian sixth grade students who participated in 4 lessons delivered via an online platform that collected all student interactions (including verbal and written comments on texts, images, and videos). In addition, we captured classroom interactions, interviews with students and teachers, and student questionnaire data. Students in partner classrooms were asked to explore the influence of the geographical location of Korea and Australia on the seasons and to consider how these differences in the season were reflected in the culture of people living in both contexts. Communication during the video conferencing was conducted in both Korean and English languages and bilingual teachers, students, and researchers supported interactions through partial and total translation. Students were also encouraged to use electronic translators, such as Google, to support reading and writing text comments and questions in the online-platform. Students were supported to co-construct models using scientific explanations to describe how the seasons are experienced in each country. Students used worksheets to design models for their explanations, which were uploaded into on-line platform to be analyzed using a modified assessment frame. We used previous research on students' Mental Models about what causes changes in the season to help classify and interpret student's models. We

share findings about similarities and differences in students' models and students' responses to a questionnaire called the Science Capital Questionnaire for Elementary school Students (SCQES). The SCQES measures the kinds of science capital that students bring with them to school. To develop SCQES, we drew from Pierre Bourdieu's work on capital, and a more recent reconceptualization of Bourdieu's work by other researchers, to consider how students' experiences in home, school and community contribute to the development of their science capital in the form of both knowledge and other valuable resources, such as attitudes towards science learning and science as a discipline. We developed original items and we also adapted some items from different pre and post conceptual questionnaires (each 10 items) measuring students' alternative conceptions about day and night and seasonal changes. The SCQES also collects demographic variables about students' everyday science related activities like reading, playing, studying and other factors that could influence science culture. Content validation was conducted by inviting science educators and primary school teachers. Our findings suggest students have significant differences in science capital in each country. However, the factors that influence students' science capital were very similar in each case. We discuss how students' explanatory modeling process and their conceptual development about the seasonal change could be influenced by students' science capital. We offer suggestions for future research about the impact of arts-integrated STEM programs on the quality of students' modeling and on their conceptual understanding.

[27O3I-4] Examining the Impact of STEAM Education on Cross-cultural Science Learning with Australian and Korean Elementary Grade Students (*A0438*)

Hey-Eun Chu[1], Kongju Mun[2], Sonya N. Martin[3], Seung-Urn Choe[3], Taesil Jeong[3], and Jinwoong Song[3]

1. Macquarie University, Australia, 2. Ewha Womans University, Korea, and 3. Seoul National University, Korea

ABSTRACT The aim of this presentation is to introduce a multidisciplinary approach to teaching and learning science using STEAM (Science, Technology, Engineering, Arts and Mathematics) activities in grades 3-6 designed to increase Australian and Korean students' awareness of cultural differences and similarities between people in both countries. In this group presentation, researchers will introduce the concept of STEAM Education and will describe the overall development and implementation of our curriculum program. Next, we share example lessons from different learning modules (one about "season change" and one about "media facade") to highlight different components of our lesson design (which incorporates the 5E Learning Model, spiraling curriculum concepts, and arts integration) and demonstrate how the curriculum supports students to make sense of the ways in which geographical location can shape people's experiences with different science phenomena (such as seasons). By sharing students' work samples, we will also consider how culture can shape peoples' interpretations of the same science phenomena. The lessons we developed incorporate the 5E Learning Model, which includes five stages of planning and lesson implementation, including Engagement, Explore, Explain, Elaborate, and Evaluate. In our lesson modules, all lessons were developed to support: (1) Engage - students explore and share their cultural differences through the web platform. (2) Explore - students work collaboratively with one another to explore concepts through hands-on activities. (3) Explain - students construct their own explanations of the concepts and processes about which they are exploring and share their ideas with international collaboration. (4) Elaborate - these lessons challenge students to apply what they have learned to a new situation and to build on the students' understanding of concepts in ways that extend their knowledge and skills. (5) Evaluate - students assess their knowledge, skills and abilities in the frame of cross-cultural, collaborative implementation of STEAM programs. Data from 20-25 students in Years 5 or 6 in Korea and Australia for the pilot project was collected over a 4-week period and includes interviews, video of classroom interactions, student questionnaire responses, student work samples, and all interactions recorded in the online platform. As a culminating activity, students created models to represent what they had learned. Models included paintings, drawings, sculptures, photography, or even multimedia presentations, such as photo voice short films or poems. In analyzing our data we are evaluating the effectiveness of the curriculum design and implementation and examining what students learned about science and cultures as a result of their collaborative interactions. We conclude with a brief discussion about the evaluation and implementation of the program with a focus on what can be learned about science teaching and learning when engaging in cross-cultural analysis and interpretation. We offer implications for STEAM education and ideas for future research and international collaborative learning projects.

[27O3I-5] A Framework for Assessment of Socio-scientific Argumentation (*A0054*)

Nina Christenson

Faculty of Health, Science and Technology, Karlstad University, Sweden

ABSTRACT The ability to produce a convincing argument with evidence to support a claim is important for participants in a democratic society. Research on students' argumentation and reasoning on socio-scientific issues (SSI) has been extensive over the past decades due to its importance in science education. SSI provide a context where students can engage in reasoning and argumentation that involves the generation and evaluation of positions in response to complex issues which often lack definite solutions and have links to science and implications in society. Research includes a great variety among the analytical frameworks that have been developed to study students' arguments. Most of these frameworks focus on either the structure of the argument or the content and are hard to use due to its complexity and in some cases more suitable to scientific argumentation rather than informal argumentation on SSI. Consequently, there is a need for frameworks that analyze the overarching patterns of socio-scientific arguments related to both the content as well as the structure. Accordingly, this framework should not be too complicated in its organization but possible to be used for assessment purposes for teachers as well as students own practice in order to improve their argumentation. Consequently, the aim of this research is to present a new analytical framework with focus on content, structure and the nature of the justifications that can be applied on socio-scientific argumentation. This framework

is presented by applying it to authentic grade 12-students' written arguments on a SSI about genetically modified organisms (GMO). There are two main components relating to the structural aspects: claim (decision) and justification (with pros and cons). Justification is defined as a combination of data, warrant and backings. The justification(s) that the arguers state in favor of their own claims are the pros and the justification(s) the arguers state against their own claims are the cons. Moreover, the justification can consist of value-laden statements when the arguers express their values on the issue and/or knowledge based statements when the arguers use conceptual knowledge to support their claims (and the content in the pros and cons are part of the content aspects, se below). The content aspect (knowledge) in the justifications (can be both pros or cons) is presented as different subjects that are based on the conceptual knowledge linked to a specific field or discipline such as politics, chemistry, economy etc. that arguers use in their justifications. Clearly, it is of great importance that the conceptual knowledge is relevant and scientifically correct, and this is why an explicit category about the conceptual knowledge is added to the framework:
A. Correct and relevant content knowledge included
B. Non-specific general knowledge (not directly related to the issue/focus)
C. Incorrect content knowledge included (misconception or superficial scientific knowledge)
This framework explicitly includes bot the structural and the content parts of a valid argument and will be fruitful both for future research on informal SSI-argumentation as well as in science education where the framework can be used as a tool assessing arguments considering both structure and content and consequently to assess the arguments as a whole.

[27O3I-6] Exploring the Elements of Music in Creating Experiences of Scientific Concepts (*A0407*)

Enrico Benjamin N. Reyes
Harris Memorial College, The Philippines

ABSTRACT Music is now integrated in the teaching of Science and Math especially in the preschool. Music creates opportunities for children to experience scientific concepts and make those concepts culturally relevant and meaningful to them. In this study, nine students aged five to eight years old enrolled in the iHarris Academy to experience and learn Science and Math through creative ways, and through Art and Music. The program ran for eleven days: eight days of integrated classes, one day for field trip, one day for the preparation of their presentations, and one day for the graduation. Musical experiences were created in the same way that the Elements of Music (rhythm, harmony, melody, texture, color, form, dynamics, and tempo) are manipulated to create a composition to immerse students in musical experiences related to scientific concepts presented in the program: Sound, Volcanism and Yeast Reaction, Mixtures, Air, Electrical Circuits, Day and Night, Motion, and Water. Children experienced the scientific concepts through songs, games, rhythmic activities, and instrument playing.

<3J> Informal Settings

Chairs: Yeh Jung-Hua (National Museum of Natural Science), Xerxes B Dulay (Harris Memorial College)

[27O3J-1] The Role Identity of Science Museum's Curators should have: Much Educator than Scientist (*A0372*)

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ABSTRACT The science museums' exhibition areas are getting larger than 15 years before, but educational staffs are decreasing in Taiwan. The curators in science museum are expected to handle both general science education for citizens and their own science majored research. The self-identity in science learning effects on selecting teaching aids, objects interpretation and communication style. What self-identity in science learning do science museum curators have could benefit the science museum most? This study tried to inquire after science museum curators' identity toward science learning through their working history. Three senior science museum curators' working history included in this study. These curators worked in three different main science museums at least 15 years in Taiwan. Two of them majored in biology, one majored in science education. All the three curators were in charging of education programming during the past 10 years. The research draws on qualitative approach. Data collected by semi-structure interview. Interview transcribed analysis by the scheme which explored the participants' identities toward science learning; how did the participants feel and value a curator should contribute to science education. The research found the self-identity toward science learning of curators are divergent: the two biology majored curators felt that they need to deliver high quality of science knowledge; the science education majored curator paid attention on introducing new science teaching/learning approach to the visitors. All them treated the science museum located communities as important partners in education, and the most important goal of museum science learning is the attitude toward science/ ecology. In museum science education practices, two biology majored curators provided knowledge or objects as resources to teachers for designing teaching activities which relate with science museum; the science education majored curator identified herself as cooperative worker who engaged in the processes of museum teaching activities development and encouraged teachers to teach in the way which different from they used to be in school. According on their opinions, the implication for museum practice and the influence for science learning practice in museum proposed as below: 1. It is important to have the supporting from the science museum located communities (local communities, teacher communities and citizen communities). 2. Science museum offered free workshops, family science affairs and teacher seminars to the community members benefits both social communities' science identity and local supporting to museum's operation. 3. Curators offering science information to teachers could help teachers quickly producing science museum related teaching materials. 4. Curator provide the scaffolding base on scientific concepts and objects (exhibits) could help teachers to develop the science discourse encourage profession. 5. Some suggestions for

writing popularization of science articles or label text, ecology education through artist and integration science education theory in science museum affairs.

[27O3J-2] How Can We Practice "Students' Science Practicing?": The Process of Students' Issue Identifying in Science Fair (*A0135*)

Hui-Chuan Chang* and Huei Lee
Graduate Institute of Science Education, National Dong Hwa University, Taiwan

ABSTRACT A lot of key literature has demonstrated the crucial role of practice in science education (NRC, 2012; Osborne, 2014). However, by educators' own admission, there is still much to be done to see this happen both in teacher education and actual teaching at school (Crawford, 2014, p.537). On the other hand, science fairs which combine inquiries with practice have been out there for year. Treagust contends that the best examples of open inquiries are not part of the formal curriculum but rather offered through scientific competitions (similar to science fairs) organized by science teacher (Abd-El-Khalick et al, 2004, p.409). This sheds new light on the theory and practice in science education. The biggest challenge students may encounter when scrutinizing a subject is to identify a valuable research question. The teacher in the following case study has supervised student science projects for 13 years at the primary school and has collected 13 awards. The qualitative research approach and analytic Induction method was adopted in this study, the researchers analyze detailed process records, such as teachers' self-reflection notes the past 10 years, teaching journals, students' progress notes, etc. Thanks to the Internet, the past 5 years have witnessed communication between students and teachers going online, e-mails allowing correspondence transmitted fast and well preserved. The study results showed that the teacher in point tends to have students' personal interests as the main drive and once the topic get pin-pointed, the instructor goes one step further guiding students to examine the project's feasibility and compare students' proposal with past literature with the hope of identifying potential flaws of the proposed project. When there is indeed a flaw, students are encouraged to either defend for their decision or to manage to come up with a commonly agreed-upon research design via group discussions and peer evaluations and, through pilot study, to better their study question. Such a process which involves reading, writing, argumentation and practice-pilot study not only helps let the research topic and study question jell but also allows students room to develop the ability to conduct an actual research project. It well supports this notion: "… the actual doing of science or engineering can pique students' curiosity, capture their interest, and motivate their continued study" (NRC, 2012, p.43). Lastly, a teacher's effort in building a safe environment that encourages communication is a key element for instigating team work, and related results also are discussed in this paper.

[27O3J-3] The Effect of Game-based Learning on the Marine Environmental Protection Issue (*A0312*)

Min-I Lin, Keng-Hsuan Chang, and Chia-Cheng Yeh
National Museum of Marine Science & Technology, Taiwan

ABSTRACT This program has been conducted for 4 years and 289 students deployed to ASEAN countries as teacher trainees. Based on student's 'experience' reflection post TWINCLE program, the effects of the program to students were evaluated for developing a better internship activity. In this research, we analyzed student's experiences through open-ended surveys using text mining. These surveys focus on the learning and growth experiences of students throughout the program while preparing the science classes over the course in one semester. The results showed that through TWINCLE activities, students were able to overcome various difficulties and able to acquire the skills to carry out activities in a global society. In addition, through this program students were able to experience intercultural exchange, teaching experience and growth by planning classes.

[27O3J-4] The Utility of the Board Game for Structural Concept of Solar System and Learning Motivation: An Astronomy Board Game for Elementary School Students (*A0376*)

Ping-Han Cheng*, Ting-Kuang Yeh, and Chun-Yen Chang+
Graduate Institute of Science Education, National Taiwan Normal Univrsity, Taiwan

ABSTRACT The purpose of this research is to design and evaluate an astronomy board game to promote students' conception of the solar system. The concept of solar system is of great importance for astronomy education. However, because of its complex structural concept, massive range of knowledge and sophisticated operations, students often find it difficult to learn. To enhance their motivation and learning effects, board games can be an advantageous learning tool. If we can design and use board games properly, they could be useful in astronomy education, to stimulate students' interest and to expose them to the understanding of the concept. In this article, we developed a board game called "Solar System Traveling" (SST) for astronomy education. SST was designed with the scientific concept about the information of the solar system, including the principal characteristics of the main members of the solar system, and the major elements of the Earth. In addition, SST was designed to engage students in an informal way of competiveness, involving active and dynamic group gaming processes. SST is constituted by cards and a game board. Each card stands for the information of a member in the solar system, while the game board stands for the whole solar system. In the game, the player who is the first to collect seven majors elements of the Earth will be the winner. To collect those elements, the students must put out a card in each turn. If the card is put in the correct place on the game board, it would start up its gaming effect, such as winning an element, decomposing an element, or picking up an element from someone else. To evaluate the effectiveness of SST on elementary school students, a pretest-posttest quasi-experimental design was adopted with a total of 21 participants. The participants were selected randomly from grade 5 to grade 6 students. In the beginning, they wrote the concept assessment and the motivation questionnaires, and then they played the board game in 2.5 hours. Finally, they wrote the same instruments again and went through interviews. Data analysis was used by paired t-test to find out significant differences in students' performance among each

instrument between post-test and pre-test. Results indicated that after playing SST, students appeared to have more, and higher level of outstanding knowledge of the solar system than they had been in pre-test. Moreover, their astronomical conception became structural. They also showed high motivation in learning astronomy and positive interest in playing this game. Based on the results and interviews, we got the following findings about how SST provided effective learning for students. First, the knowledge of the solar system is obviously revealed by the theme design of SST. Second, the rules of SST can construct the structural conception well. Third, the gaming processes make students engage themselves in SST. Additionally, they can remember the information it provides. Because of those findings, we believe SST can promote students' learning performance in astronomy education.

[27O3J-5] Preliminary Exploration of the Informal Science Learning Environment Questionnaire (*A0397*)

Jen-Che, Tsai* and Chun-Yen Chang+

Graduate Institute of Science Education, National Taiwan Normal University, Taiwan

ABSTRACT This study's purpose was to develop an instrument that was the informal science learning environment questionnaire (ISLEQ). In addition, this study also attempts to explore the participants' learning environment preferences and participants' learning environment preferred-actual perception gaps on the informal science learning environments. The informal science learning environment questionnaire (ISLEQ) developed five scales: integration & connectivity, environmental interaction, instructor support, environment support and preparation & organization. In this instrument, there were 29 items were constituted using Lykert type scales. According to our collected data, the total valid samples were 199 participants came from Grade 1 to Grade 12, study in Taipei City. In fact, all of the participants were selected by random sampling to respond the instrument in the informal science learning environment of the Taipei science day activity on May 30th, 2015. This instrument design pretest-posttest to measure the participants' learning environment preferences and participants' learning environment preferred-actual perception gaps. In general, the entire questionnaire's Cronbach alpha was 0.97; the each scale of Cronbach alpha ranged from 0.85 to 0.92. Besides, the ISLEQ instrument showed, the participants' learning environment perception was a significant correlation ($p < 0.01$) with participants' scientific motivation ($r = 0.63$), and with participants' learning satisfaction ($r = 0.87$). Past research indicated that students' learning environment preferences will affect students' science motivation. However, past studies about learning environment preferences were more focused on the formal learning environment, less studies concentrate on informal learning environment. The results of this study showed, the most participants' preferred of learning environment scales were environment interaction ($M = 4.40$, $SD = .59$). However, the participants' learning environment preferred-actual average perception scores were negative, which showed the participants' final perceptions were disappointed with the environments. At our suggestion, although the participants' preferred-actual total mean perceptions were negative, it does not indicate the informal science learning environments were not good. It represented, the participants have more expectation on the informal science environments. It is interesting between participants' preferred and actual perception gaps. The gaps can show participants' personal preferred-actual deviation. If the gaps are more larger, the participants' perceptions are more different with their preferred. The participants in this study showed two large gaps of the scales were instructor support ($M = .56$, $SD = .53$) and environment support ($M = .59$, $SD = .55$), which indicated the informal science learning environment could not complete in line with the participants' preferred. Because of the participants have higher motivation, so their standard of expectation also higher when participants according to their preference to participate in scientific actives. At our suggestion, to consistent with participants' preferred, the scientific actives organizer should provide user-friendly interface and a more detail description about their subjects and activities. Then, the participants can understand which scientific actives they really want to participate in. In conclusion, the ISLEQ instrument aimed at improving the informal science learning environment effect, and participants' preferred-actual perception gaps on the Taipei science day have provided an empirical data for how consistent with participants' preferences. The results can be improve informal scientific education setting.

[27O3J-6] The Use of Alternative Materials for Hands-on Approach in Science Education for Young Learners (*A0461*)

Xerxes B. Dulay

Harris Memorial College, The Philippines

ABSTRACT Teachers commonly use lectures and textbooks to convey Science concepts to students just to end up with a sub-standard learning output. Research says that the hands-on approach in Science education enhances the achievement of the learners. However, the implementation of this approach becomes challenging due to the lack of a well-developed curriculum, inadequate number of teachers with expertise, and expensive facilities and equipment. The iHarris Academy was developed consisting of teachers in Physical Science (Biology, Earth Science, Chemistry and Physics), Mathematics, Art and Music. Randomly, nine learners of ages 5-10 were enrolled in the 10-day summer program. The lesson includes volcanic eruption, solar and lunar eclipse, light and sound, mixtures and colors, motion, power and electricity. These lessons are implemented through hands-on activities using common and inexpensive materials available in the community such as mineral water bottle and straw, leaves and twigs, etc. Sample activities includes volcanic eruption model, improvised lava lamp, dancing sprinkles (seeing sound), eclipse model and simulation, balloon-powered car, doing a simple circuit, mixing food colors, doing an improvised anemometer, yeast power, floating egg, and thirsty plant drinking water. Investigations also included the use of the compound microscope and specimens, and mobility of organisms in pond water. The learners are then led into the self-discovery of concepts using guide questions and samples. Mathematics, Art and Music are integrated in the learning process. The teaching method is the same to all the learners. An educational tour was held on the fifth day exposing the learners of the Sciences in the environment. A culminating activity was held on the last day demonstrating their

favorite experiments and explaining the Science concepts behind them. The output of this program is an evidence that 1) even at their young age learners use higher order thinking skills (HOTS) to understand and explain Science in their environment, however, varies in the level of learning achievements, 2) learning achievements in Science are improved using hands-on approach, facilitated by trained teachers with expertise, and integrated with Mathematics, Arts and Music, and 3) inexpensive and common materials available in the community could be used as alternative for hands-on Science experiments.

<3K> Teaching/Learning (Curriculum/Teaching Materials)
Chairs: Chuan Li (Beijing Normal University), Xiaomei Yan (University of Bristol)

[27O3K-1] Explore One Tertiary Chemistry Laboratory Course from CHAT Perspective (*A0463*)

Xiaomei Yan* and Justin Dillon
University of Bristol, UK

ABSTRACT Educators have advocated a reconsideration of the nature of laboratory activities, including tertiary chemistry laboratory work. The insufficient issues of the science laboratory course were well acknowledged across education levels. The specific issues, including the diverse learning objectives of the tertiary chemistry laboratory education (what to learn) and inefficiencies of the traditional type of laboratory (how to learn), are addressed in this paper. In order to obtain in-depth understandings regarding these issues, science educators suggested to identify these issues within their institutional, social and historical context. In response, Cultural Historical Activity Theory (CHAT) as an integrating and flexible social cultural theory, offers heuristic perspectives to explore the complex learning environment in tertiary chemistry laboratory education. This paper examines second year chemistry students' learning during laboratory work through CHAT perspective. The empirical study took part over a period of three months in an undergraduate Chemistry course in a prestigious English university. Data collection was guided by CHAT, using individual interviews, observations and documentary analysis. The participants included 12 students working in three groups of four, five demonstrators and four course tutors. They were part of a larger cohort of 147 students, 26 demonstrators and five course tutors in a second year chemistry laboratory course. Engerstrom's triangle model was adopted to draw the holistic picture of the laboratory course, on the basis of data collected from different sources. Guided by CHAT, the laboratory course was regarded as one activity system. The analysis of the activity system with Engerstrom's triangle model provides insights into tertiary chemistry laboratory education (TCLE), especially the issues of diverse learning objects and disengagement of students in traditional laboratory. The finding identified the different orientations towards the object among the tutors, students and demonstrators. The students' and demonstrators' views agreed with the shift in the literature on epistemological understanding of chemistry in scientific laboratory education, which is different to tutors. Moreover, the laboratory course made use of an ICT supported learning environment (DLM) and formative assessment schemes in order to tackle the well documented problem of students' pre-occupation with procedures in the laboratory. The assessment schemes were across the pre-lab, in-lab and post-lab stages of the laboratory course, assessing different aspects of students' learning. However, the findings identified the issues of students' disengagement with DLM in pre-lab and the transferrable issues of information in DLM to the operations in the laboratory. Furthermore, the demonstrators' roles were highlighted in this activity system. This finding supports the previous studies on roles of post-graduate teaching assistants (GAs or TAs) in teaching and learning in tertiary science education, including the chemistry laboratory context. However, the findings indicated that the subjects placed different a focus on the demonstrators' roles, and the mismatch between the demonstrators' receiving training and their responsibilities. In summary, the discussions regarding the interactions within the activity system shed new lights into the issues of TCLE. Guided by CHAT, the inconsistencies between the objects and the learning context were highlighted.

[27O3K-2] Developing Students' Scientific Literacy Insight of PISA in Combustion Instruction in Middle School (*A0230*)

Chuan Li*[1], Kewen Liu[1+], Xiaoying Feng[2], Yan Zhu[3], and Lin Yan[4]
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ABSTRACT Program for International Student Assessment （PISA） sponsored by Organization for Economic Co-operation and Development （OECD） interprets the meaning of scientific literacy from the perspective of development of 15-year-old middle school students, which focus on their adaptive ability in their social life in the future. PISA 2015 concentrates on procedural and cognitive knowledge (i.e. the nature of science) during the construction of systematic scientific knowledge, the understanding of process and methods in science research as well. In PISA 2015 assessment, application of scientific knowledge in social life has been detailed and distinguished, highlighting the role of science in problem-solving process. Meanwhile, the number of multiple choice items has been increased by the use of computer technology to simulate the real process of scientific data generation. Therefore, students not only get to know scientific knowledge itself, but also how the knowledge was constructed. That is to say, students' thinking process in dealing with scientific problems has been stressed and focused finally. Combustion phenomena are the chemical reactions closely related to human life. It has been known about 500,000 years ago. However, scientists' investigation for the nature of combustion started in the mid-17th century, which became a significant symbol for the birth of modern chemistry. Therefore, combustion is the basis for secondary school chemistry. Learning the concepts of combustion phenomena, combustion condition and the principle to put out a fire, understanding chemical ideas and methods implied in combustion topic, and experiencing the process to establish the scientific knowledge relating to the theme of combustion plays an important role in the cultivation of secondary school students' scientific literacy and understanding of the nature of chemistry. By the analysis of PISA2015 scientific literacy interpretation, the topic of combustion has fundamental role in improving secondary

school students' scientific literacy. In the teaching practice, the clue of core questions was confirmed, including "what kind of combustion phenomena are there in students' life?", "which substance are burned in those combustion phenomena?", "what are the conditions of burning material?", "what are the advantages and disadvantages of combustion reaction?", and "how do people use the understanding of combustion topic to make our life better?", and to explain people's utilization of burning phenomena. Based on those questions, instructional design covering the clue of teaching contents, core questions, situation material, teachers' activities, students' activities and design goals was constructed. For example, the clue of teaching contents is from listing the combustion phenomena to knowing those combustible in the proposed phenomena, to exploring the combustion condition, to studying how to reinforce or weaken those combustion phenomena, and to explaining the advantage or disadvantage of combustion phenomena for human. The results of students' performance in pre- and post-tests involving one-choice, multiple-choice, open-ended, and other form items, which are designed by researchers themselves based on the interpretation of scientific literacy in PISA 2015, demonstrate that there is a significant difference of the participators' performance between pretest and posttest, and students' scores in post-test rises obviously.

[27O3K-3] Students' Prior Conceptions about Knots (*A0154*)

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ABSTRACT Knots theory now plays an increasing role in various fields of sciences, with applications spanning from large biological molecules to quantum computers. Some countries, for example Japan, have attempted to teach basic knot theory at school levels. But mathematical knots are different from physical knots that students have encountered in daily life. When a teacher makes the analogy that a circular deoxyribonucleic acid (DNA) molecule is like a knot, it is to the mathematical knot that is being referred. However, what the students perceive this to mean will largely depend on their previous experience with physical knots. This experience may unduly impede with their learning of important scientific concepts. It is thus natural to ask, "What do students know about knots prior to hearing that a certain objects in the scientific domain is analogous to a knot?" Since basic knot theory is not yet formally introduced in the curricula of Taiwan, a teaching experiment was organized to feasibility of teaching this topic to seventh graders. The focus of this paper is to identify what concept images students had prior to and after the instruction. Qualitative research and convenience sampling were used in this study. In 2015, twelve students from five classes in a public junior high school in Taipei agreed to participate in this study after they had enrolled in an extracurricular class on the art of tying cultural knots. Prior to instruction, they were asked to tie a knot and explain whether it could be untied. After gluing the two ends together, they were again asked to explain whether the glued object was a knot and whether it could be untied. Eight classes were then delivered with emphasis on using strings to make cultural knots. The mathematical conception of a knot was informally introduced. After instruction, we presented the participants a knot made from a string laid on the plastic plate and another one made presented by a knot diagram. They were asked whether they regarded these two objects as knots and whether they could be untied. Due to the limitation of space, only finding from the pretest was reported. Prior to instruction, all twelve students could tie a knot and agreed that the knot they tied could be untied. Yet after the two ends were glued together, only eight students declared that it was still a knot. Most based their discernment on the equivalence between the original and new structures. Only three students claimed the glued knot could be untied and none could explain their reasons explicitly. Apparently, the participants had a robust concept image in that a knot is comprised of a knot-like object with two open ends. When the two ends were glued together, some would consider it no longer a knot. Furthermore, most would agree that if physically breaking a glued knot was prohibited, then it could not be untied. The implication from this study on mathematics education is an important one. Students' prior conceptions about physical knots need to be accommodated before they can grasp the mathematical definition of a knot and unknot.

[27O3K-4] Curriculum for Improving First Graders' Logical Reasoning and Problem Solving: An Example of Bridge Game (*A0018*)

Yun-An Chen[1], Chun-Yen Chen[2], Kuo-Wen Chen[3], and Fu-Pei Hsieh[4]*+

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ABSTRACT People can improve creativity and mind through bridge game. For beginners, they can learn to compare numbers, sort by size and classify. It's worth popularizing in compus. To enhance students' pleasure, we design bridge course to make them use mathematical knowledge ability, then encourage students using logical reasoning to solve problem. Qualitative research, interview, video and photos were administered to record teacher's instruction and students' reaction. Researcher as the teacher in this study, having five years teaching after-school bridge club experience. 25 first grade students in researcher's class were selected. The findings were: (1) There are high correlations between four math units and bridge activity, for example, Unit 1 is Count to 10, Unit 4 is Order and numbers, Unit 5 is Count to 30, and Unit 7 is Knowing shape. Then, analyze the concepts to compile courses, step by step, let students start with classifying colors, then use bridge rules to teach students how to sort by size, compare numbers. Last, make students apply mathematical knowledge ability by holding simple NT and trump contract competitions, for raising their logical reasoning and problem solving abilities. The bridge curriculum was summarized below: 60 minutes was used in the one day activity. First date, Classification according to color, Sorting by size, Comparing numbers. Second date, Shuffling and dealing cards, Classification and sorting, Knowing NT contract, Following and discarding cards. Third Date, Knowing trump contract and ruff. (2) Performance: For assessing students' understanding, we gave one student a pair of poker. Then asked them to classify, sort cards, and so on. First date: 21 students(84%) could classify cards

according to four colors, four students(16%) couldn't. 18 students(72%) could sort cards by size, 2 students(8%) made mistakes in some colors, 5 students(20%) couldn't. Second date: Every student could Shuffle and dealing cards (100%). 6 students(24%) could classify cards according to four colors and sort by size, 5 students(20%) made mistake sorting a hand, 5 students(20%) made mistake sorting two hands, 2 students(8%) made mistake sorting three hands, 7 students(28%) made mistake sorting four hands. Third Date: 18 students(72%) could play no trump contract, but 7 students(28%) couldn't. 22 students(88%) could play trump contract, but 3 students(12%) couldn't. (3) Property for teaching first-grade students bridge: After playing bridge, students were asked: " Is bridge fun? Do you like it? " , every student answered: " Fun! I like it!". Conclusions and Implications were: (1) Proper bridge course makes students apply mathematical knowledge ability. We found that more than 70% students can apply mathematical knowledge, raise their logical reasoning and problem solving abilities. Clearly, if bridge rules can fit students' cognition level, they will enjoy math through playing bridge. (2) At first, we simplify bridge rules and teach "Just make" to avoid students' frustration during counting points. In addition, we will teach double-digit addition and subtraction in Mathematics curriculum the next semester, then we will teach "mini bridge".

[27O3K-5] An Empirical Research on Implementation of Scientific Inquiry in Junior High School Science Teaching (*A0247*)

Huang Xiao, Wei Fangbing, and Bao Chengcheng
Zhejiang Normal University, China Mainland

ABSTRACT The present study explores ways to enhance junior high school students' ability of scientific inquiry. "Does the students' ability of scientific inquiry with regard to the treatment stressing on different aspects of scientific inquiry in science teaching" is the overarching research question of the present study. Using the definition of scientific inquiry of N.G.Lederman, which contain inquiry begins with question, not necessarily a hypothesis, different levels of scientific inquiry is existed. 31 junior high school students of one class from Xiushan school in Wenzhou, Zhejiang province were chosen as the experimental object. The VISA instrument, together with the research based on the life related questions solving, was used to assess students' understanding of different elements. As to the treatment, different level goals of scientific inquiry were constructed according to the question/procedure/conclusion. Due to the important of the question and task for scientific inquiry, we designed different types of questions and its presentation methods, such as question card, question chain and question net, to inspire students' question awareness, generation and propose of questions. Also we emphasize design, development and use of different forms of task lists in scientific inquiry teaching, guiding students to experience the process of designing the task lists based on STSE, science and technology phenomena in museums and technology and production. Using the instrument of scientific inquiry from N.G.Lederman, the improvement was observed in students' understanding on "no single method", "inquiry begins with a question", and "there is no single set and sequence of steps followed in all scientific investigations". The improvement of scientific inquiry ability is also shown in the analysis of students' scientific inquiry projects, explored questions can be put forward, data from experiments were provided to argument the conclusion. Students' achievement of the test, the ability to solve problems, and the thinking all developed.

[27O3K-6] Using Concept Maps and Animations to Support Students' Learning in Chemistry Equilibrium (*A0399*)

King-Dow Su
Department of Hospitality Management, De Lin Institute of Technology, Taiwan

ABSTRACT The purpose of this study focuses on using concept maps and animations to support students' chemistry learning. To facilitate students' conceptual understanding and algorithmic proficiency of Le Châtelier's Principle in chemistry equilibrium. 112 participants were recruited from the two classes of a chemistry course, both of which were taught by the same teacher. This study took the quasi-experimental approach for two divisions of group students. The experimental group students were taught with concept maps and animations in chemistry equilibrium, and the control group students were instructed with traditional text lectures. All data were collected from students' learning achievements in posttests and retention tests, learning attitude questionnaire and feedbacks of semi-structure interviews. The statistical results of this study showed that experimental group students' post-test scores and scores of adjusted retention were superior to those of control group students. The results proved that the representations would be appropriate for students' recognition adjustments in retention learning. Most learning results confirmed that these applications would be available for students' conceptual recognition growth to fill up the learning gap between conception and algorithmic chemistry. With concept maps and animations, this study would help students construct more positive learning achievement and attitude in conceptual understanding and algorithmic proficiency. All research results also exemplified a new perspective of many researchers for students' meaningful learning in chemistry equilibrium.

<3L> Learners (Teachers)

Chair: Chih-Hsiung Ku (National Dong Hua University)

[27O3L-1] Science, Language, and Literacy: How to Help Students Develop Their Reading Understanding in the Science Classroom (*A0315*)

Shih-Wen Chen*, Wen-Jin Yang, and Chih-Hsiung Ku+
National DongHwa University, Taiwan

ABSTRACT With the increasing concern about the issues among science, language, and literacy, the reading literacy has been emphasized in school science teaching. Science teachers in Taiwan also know its importance for pupils, but they would need more clear ideals of how to conduct an implementation in their science classroom. This article aims to develop the implementation of reading science for teachers, and to investigate its effects in the science classroom. From the literatures and teachers experiences, pupils typically fail to recognize the subjects of the sentences, nominal group patterns, and semantic relations among concepts while they read the science texts. So we

develop the Science Reading Instruction (SRI). In materials, we highlight the subjects in the sentences, identify the nominal group patterns, and classify the semantic relations in texts. In pedagogies, teachers teach pupils to survey the outline of texts, ask the questions about the sentences, read and answer their ideas, share the discussion, and review the results. 99 pupils of grade 5 from a primary school participate in this study, and they are assigned into four groups of Material, Pedagogy, Combination, and Regular. The quantitative data from three worksheets were analyzed through percentage and t-test. The results revealed that pupils got a better reading understanding after SRI, particularly for those low-achieved (under PR30) pupils than those pupils without SRI. Additionally, the low-achieved pupils needed more scaffolds from their teachers to help them read to understand better. In conclusion, reading literacy is one of the essential elements to help pupils read to understand better in their science learning, and science teachers would play the crucial role in coaching and guiding pupils to develop and improve the reading literacy in the science classroom.

[27O3L-2] Reflective Thinking Approach Open Inquiry Learning Model and Experiment (*A0332*)

Yu-Chin Chou* and Chih-Hsiung Ku+
National Dong Hwa University, Hualien, Taiwan

ABSTRACT Since 1960, the practice of inquiry learning model focuses mainly on the acquisition of scientific knowledge and skills. This results in intellectualism of inquiry learning activities, and indirectly hinders the development of non-knowledge aspects of individuals. From the educational standpoint, children's inquiry are not equivalent to adults' inquiry. As the result, children's inquiry learning should not and could not be limited to the discovery of scientific knowledge and laws. It should be treated as a means for children to understand the world and to develop their unique ability to recognize the societies and environment they live in. With this belief, we assuming that children possess enough innate ability to learn the world with their peer groups through open inquiry, and they can take the learning responsibility and faces the difficulties and challenges they face through the process of inquiry, so we construct a reflection-inquiry learning theory and model to rectify the traditional inquiry learning model. In this study, we try to answer the following questions: 1. How to establish a reflective-thinking approach open inquiry learning model? 2. What difference between reflective-thinking approach learning model and traditional inquiry learning model? Through theoretical analysis, we break down the theoretical basis of reflective-thinking approach inquiry learning into the following four propositions: 1. Reflective thinking can move the inquiry activities forward in a positive direction. 2. Reflective thinking is the meta-cognitive mechanism for inquiry learning. 3. Students can enhance psychological empowerment through reflective thinking. 4. Inquiry activities enable children to refine their reflective thinking skills. The results of experiment study show the students in reflective-thinking approach inquiry learning group performs better than those in traditional inquiry learning group in the subject knowledge areas as in "total store", "proposition", and "cross link" of concept maps. They also perform significantly better in "linking community", "self-awareness" and "psychological empowerment". Based on the above results, we provide suggestions for future application in teaching and direction for further research.

[27O3L-3] Developing Elementary Students' Inquiry Skills in the Situational Interest-based Inquiry Lesson (*A0129*)

Wen-Cheng Chen* and Chih-Hsiung Ku+
National Dong Hua University, Hualien, Taiwan

ABSTRACT In the decades years, inquiry has been viewed as an approach to learning science that involves a process of exploring the natural or material world. The effectiveness of inquiry in science teaching and learning has been supported by a wide range of empirical work. However, inquiry teaching was not widespread in real science classroom all around the world. Studies have shown that science teacher did not teach science in inquiry approach because of the teaching time limit and textbook-centered belief. Therefore, it is important to develop a more practical inquiry teaching module to encourage teachers to adopt inquiry teaching in the science classroom. Besides, the students' emotional and motivational beliefs can influence the direction of thinking as they attempt to adapt to the different constraints and demand placed on them by the tasks and activities they confront in classrooms. Interest could be views as an emotional factors and really played a crucial role in the learning process. Studies also showed that novelty and task-based activity were the main source of students' situational interest in science learning. This study defines inquiry as a task-driven learning process. To help students, especially the middle- and low-science achievers', learn science through inquiry, we develop a framework for inquiry learning that involves four phased: Demonstration, Hands-on, Minds-on and Report. The lesson involve novelty and task-based activity was designed to arouse students' situational interest, and to facilitate their inquiry ability by using the structured sequence. The purpose of the study was to investigate students' progress in inquiry ability after the inquiry learning lesson. The quasi-experimental method was adopted in this research. The subjects were 83 upper graders of 3 classes at the eastern Taiwan elementary schools. Fifty-six students from two classes were selected as experimental group. Twenty-seven students from one class was assigned as comparison group. About every two students from experimental classes were assigned into one group for co-learning in a single 80-minute inquiry learning lesson. The inquiry learning lesson included four-units which students had learned the science concepts before. We perform the all four units in one year. The instrument "Student Inquiry Ability Self-assessment Scale, SIASS" , developed by Yang and Wang (2007), was adopted in this study. There are five sub-scale in SIASS including problem understanding, observation and recording, data collecting, data explanation and knowledge construction. The results indicated that: (1) experimental group students aware themselves made significant progress on inquiry ability through inquiry learning lesson, (2) high-science achievers made significant progress in data collecting and data explanation, (3) middle- and low-science achievers made significant progress on problem understanding. Based on the research finding, the implications for science teaching and learning were discussed too.

[27O3L-4] Scaffolding the Concept of Density for Elementary School Students with Guided Inquiry Strategy (*A0131*)

Chia-Cheng Yeh[1]*, Chih-Hsiung Ku[2+], Tso-Chung Sung[1], Li-Shu Chen[1], and Wen-Jian Su[1]

1. Exhibition and Education Division, National Museum of Marine Science & Technology and 2. Department of Curriculum Design and Human Potentials Development, National Dong Hwa University, Taiwan

ABSTRACT Elementary school students see objects floating on water or sinking in water in their daily lives. The objects which float or sink are related to the concept of density. Density is an abstract concept and difficult for elementary school students to experience or to imagine. Using guided inquiry strategy as a scaffold for elementary school students to aware the concept of density is the purpose of this study. The material used in guided inquiry was the handmade autonomous underwater glider (AUG), which composed of Styrofoam, a leaden counterweight (25gw), and one piece of milk paper box. The guided inquiry strategy in this study used predict-observe-explain teaching sequence to understand students' initial and final ideas of density. Guided inquiry strategy steps in this study were listed as follows: 1) Ask students if one piece of 5-gram Styrofoam putting on the water, it will float or sink? 2) Ask students if one piece of 25-gram leaden counterweight putting on the water, it will float or sink? 3) Ask students if one piece of 5-gram leaden counterweight putting on the water, it will float or sink? 4) Ask students if one piece of 5-gram Styrofoam stick with one piece of 25-gram leaden counterweight, it will float or sink? 5) Ask students if one piece of 5-gram Styrofoam (in AUG shape) sticks with one piece of 25-gram leaden counterweight, it will float or sink? There were 29 low-achieving 5th-grade elementary students participating in this guided inquiry learning journey. These students came from the countryside in New Taipei City and almost low-achieving in science achievements compared with the city school students in Taiwan. Students' response had been collected by questionnaire. The result showed that 59% of students thought that the 5-gram Styrofoam would float or the 25-gram leaden counterweight would sink because its weight was lighter or heavier than water (Q1 and Q2). When students encountered the Q3, the leaden counterweight which has the same weight with Styrofoam, 55% of students used the term "density" to explain why the leaden counterweight would sink. Only 10% students thought the 5-gram leaden counterweight was heavier than 5-gram Styrofoam. There were 10% of students thought the 5-gram leaden counterweight had smaller volume than the Styrofoam. The explanation was closed to the definition of density. The Q4 and Q5 asked the students to think about the buoyancy of the same object in different shapes. There were 62% of students thought the combination of Styrofoam and counterweight would float because of the Styrofoam's shape was flat. Nearly 80% of students thought that the combination of Styrofoam and counterweight in AUG shape would sink or did not know what would happen. This showed the students did not aware of the relationship between shape and buoyancy of objects. Using the guided inquiry strategy did scaffold the students to aware the relationship of volume and weight by using the term "density" or by the definition of density. And the stage of explaining the definition of density should be added into the guided inquired strategy in further researches.

[27O3L-5] The Learner Autonomy of Remote Junior High School Students in Informal Science Program (*A0227*)

Chia-Cheng Shih* and Chih-Hsiung Ku

Department of Curriculum Design and Human Potentials Development, National Dong-Hwa University, Hualien, Taiwan

ABSTRACT In remote East Taiwan area, educational resources is insufficient, and the students' scientific abilities is obviously weak. However, through the autonomous learning curriculum in science could students enhance the scientific abilities and learning outcomes. Because of researchers concerned students' autonomous learning in science, and the effect of learning performance. By review the meaning of autonomy, tried to understand what the learner autonomy in science learning and what the ingredients in learner autonomy. In education, it seemed seven main attributes of learner characterizing by autonomy: autonomous learners have insights into their learning styles and strategies; take an active approach to the learning task at hand; are willing to take risks; are good guessers; attend to form as well as to content, that is, place importance on accuracy as well as appropriacy; develop the target language into a separate reference system and are willing to revise and reject hypotheses and rules that do not apply; have a tolerant and outgoing approach to the target language. A combination of these properties, researchers designed three different curriculum, which includes: 1. Thematic curriculum units - in order to understand the situation of independent learning, researchers designed several curriculum units, that completed within five hours. e.g. "Hour of code", "projectile launchers assembly and implementation" etc. 2. Robotics competitions training – it's an entire semester course units. Through the course of the competition, and encourage students to learn. 3. Reading course - every Saturday afternoon, researchers are continuing arrangements to enhance science literacy reading program, and through action research, constantly changing interactive lessons for students. This paper adopted qualitative research methods. Data were collected from 30 7~9th grade students in remote East Taiwan area who volunteered to participate at two years program. Data collection strategies can be planned in general at the outset. For example, video recording of the class on specified days, student work (notebooks, scribbles on worksheets, and journals), interviews students and the teacher outside of class, and digital records of study course, the main way to assess students' autonomous based, and proactive learning process, to explain the performance of the special competition. The results indicated that in general, students demonstrated the expected abilities in science competition or robot competition and that their learner autonomy accurately reflected their performance levels of scientific abilities.

Oral 4 (27th, 11:30-12:50)

<4A> Learners (Teaching/Learning)

Chair: Pattamaporn Pimthong (Kasetsart University)

[27O4A-1] Longitudinal Impact of a Cooperative Inquiry-based Learning on Children's Images towards Scientists and Scientific Self-efficacy (*A0077*)

Hsiang-Ting Chen*, Hsin-Hui Wang, and Zuway-R Hong+

National Sun Yat-sen University, Taiwan

ABSTRACT This study explored a long-term effect of a cooperative inquiry-based teaching intervention on elementary school children's images towards scientists and scientific self-efficacy. Thirteen 4th grade boys and 20 4th grade girls were randomly selected to participate in a 3-semester intervention and formed the experimental group (EG), which conducted cooperative inquiry-based activities; another 20 4th grade boys and 15 4th grade girls were randomly selected to participant in the assessment and as the comparison group (CG). The Elementary School Student Questionnaire was administered to assess all children's images towards scientists and scientific self-efficacy. In addition, 6 target students from the EG with the highest scores or the lowest scores on the pretest of scientific self-efficacy were recruited to be interviewed at the end of each semester and observed weekly. Exploratory factor analyses were conducted to evaluate reliability and validity of instruments; paired-wise t-tests, analyses of covariance and content theme analysis were used to analyze the similarities and differences between groups and across semesters. It was found that EG children's total means of scientific self-efficacy and on the dimensions of successful experience and willing to learn were significantly higher than the CG counterparts. In addition, the EG children's means on the stereotypical images towards scientists were significantly lower than the CG students'. Interview and observation results were consistent with the quantitative results. Instructional implications and research recommendations are discussed.

[27O4A-2] A Study of Teaching for Conceptual Change in Primary Science (*A0302*)

Pattamaporn Pimthong*[+] and Kritsada Sanguansin

Faculty of Education, Kasetsart University, Thailand

ABSTRACT The purpose of this participatory action research was to study primary science students' conceptual development about insecticide in everyday life. There were two researchers in this study, a science educator from faculty of Education and an experienced primary science teacher. The participants were forty-three Grade 4 (9-10 year old) students from a large school in Bangkok, Thailand. A conceptual change instructional unit of chemical substances in everyday life was developed by the researchers. The second researcher was a teacher who implemented the unit, while the first researcher was a participant observer. Data were collected through pre and post concept surveys, classroom observations, student work, and student interviews. The results showed the influence of role playing as a reporter who go to interview the agriculture expert. The students need to search for data and create their own interview questions about insecticide in everyday life. They developed their understanding about insecticide by interviewing and discussion with experts and friends. The using of quality local learning resources and experts can encouraged students' conceptual change. The finding from this research showed the ways to bring conceptual change teaching approaches to classroom by working collaboratively between the science educator and the primary science teacher.

[27O4A-3] The Analysis of Question Types between Multicultural Family Students and Non-Multicultural Family Students in Elementary School Science Class (*A0510*)

HounTae Kang* and SukGoo Noh[+]

Gyeongin National University of Education, Korea

ABSTRACT The purpose of the study is to analysis the questions which come from the multicultural students and non-multicultural students in science classes and to give the implications of the roles of teachers who need to understand the multicultural students' scientific thought and teach them properly. 40 multicultural elementary school students from 3rd to 6th grade were selected as an experimental group and 80 elementary school students from 3rd to 6th grade are selected as a control group. Biology part of each grade's science textbook is chosen as a study topic to maintain the coessentiality of the study. After completed all the chapter of the class, examined the questions arising about the science class right after it is done. In the case of 40 multicultural students, 6 of them who have not learned Korean yet, the survey was conducted with the help from multicultural (China, Mongol) language teachers. For the first step, meaningful questions related to the context are chosen, and through it, figure out the frequency of the questions between the multicultural students and non-multicultural students. And using question types by Chin & Brown (2002), the question types between the multicultural students and the non-multicultural students were comprehended according to their grades, genders, nations, and the length of their stay. As a result, average question numbers are similar; non-multicultural students in grade 3 and 4 asked more questions, however, multicultural students in grade 5th and 6th asked more questions. In question types according to the grade, the rate of the basic information question (factual, procedural question) were dropped, whereas the rates of high standard questions like wonderment question (explaining, prediction, anomaly detection, expansive thinking question) were raised and there were few or no differences in the rates of the questions in multicultural students and non-multicultural students in each grade. In question types according to the science study achievement, the rate of wonderment questions became higher from the lower group to the higher, while the rate of basic information question became higher to the lower group. In question types according to the gender, female students asked more wonderment questions than male students on both multicultural students and non-multicultural students; male students asked more basic information questions. In question types according to the nations: China, Vietnam, Mongol and Korea, there is no significant differences. Lastly, in question types of the length of stay, classified two groups as local born and immigrated, the local born students asked more wonderment questions and the immigrated students asked more basic information questions.

[27O4A-4] Research about Students' Understanding of Mole Concept in High School Students (*A0474*)

Shunichiro Watanabe and Kinya Shimizu

Graduate School for International Development and Cooperation, Hiroshima University, Japan

ABSTRACT The mole concept is the important and basic topic in chemistry in secondary school level. The mole concept is appropriate tool to express property of substance

to conceive quantitative relationship in chemistry. However, learning of mole concept is difficult, because of the complexity of each word and some misconceptions of the term of "mole". In Zambia, Examination Council Zambia(ECZ) recommended that the mole concept in chemistry course must be adequately covered to give a strong background of the quantitative understanding. The objective of this study is to find some causes of students' misconception about the mole concept. In regard to the method, first, in order to find out students' method for calculation and abilities for applying values, I administered tests about stoichiometric calculation to 44 students of grade 11 at the end of the lesson of stoichiometric calculation in the mole concept. I analyzed students' calculation and investigated students' abilities for applying given value of Relative mass, Molar gas volume and Chemical equation. As a result, many students substituted different value to the formula for finding number of moles or the calculation of the ratio. In students' abilities, more than 70% of students failed to use given value correctly. In conclusion, many students recognized mole as other measurement, and didn't understand meaning of chemical equation. Next in order to find misconceptions about each word in mole concept, I instructed students to make concept maps with the key concept of "number of moles". First I made concept map based on textbook and syllabus in order to compare with students' concept maps, and then extracted wrong connection of important words for calculating chemical quantities in students' concept maps. Also I extracted important words which are not included in students' concept maps. As a result, more than 80% of students made wrong connection of these words, "Molar mass", "Relative atomic mass", "Relative molecular mass" and "Mole ratio", or didn't include these words in their concept maps. In conclusion, many students have misconception about relationship between Mole and Mass, and Mole and Mole ratio. At the end, in order to find causes of misconception about relationship between Mole and Mass, and Mole and Mole ratio. I observed lessons of topic of "Relative mass", "Mole" and "Stoichiometric calculation" I extracted teacher's explanations and sentences on the blackboard and identified which explanations effected students' misconceptions of these relationships. As a result, I found that teacher lacked explanations of connection between Relative mass and Mole in lessons of "Relative mass" and "Mole". Also teachers' explanation of quantitative relationship focused on comparison of "Mole and Mole", "Mole and Mass" and "Mass and Mass". This explanation leaded to recognition that mole is equal relationship of other measurements. This explanation was different concept of "Mole concept". In conclusion, teachers didn't focus on the relationship between "Relative mass" and "Mole", and the quantitative relationship following concept of Mole. Teachers' explanations effected students' misconceptions and students can't use appropriate value for solving calculation.

<4B> Teachers
Chair: Hongming Ma (Federation University Australia)

[27O4B-1] Exploring Science Teachers' Use of Narrative in Teaching (*A0010*)
Hongming Ma
Federation University Australia, Australia
ABSTRACT This paper reports two case studies of secondary school science teachers' teaching practice with a focus on their use of narrative. The aims of the study are to identify types of narrative adopted by science teachers, the purposes of their use of narrative in science teaching and factors that influence the selection and implementation of narrative in science teaching. This study is qualitative case study in nature with classroom observation and teacher interviews as main methods. Two secondary science teachers participated in this study, which formed two cases. The data set consists of audio recording of formal teacher interview at the end of the term, audio recording of classroom practice, handouts, and field notes. A constructivist grounded theory method was employed to guide the data analysis. The study identifies five types of narrative used by the participant teachers with purposes related to student cognitive development, affective needs, teacher-student relationship, and, teachers' actualisation of personal teaching philosophy. Factors that influence the use of narrative in science teaching include teachers' teaching style, situational factors such as student year level, and, the interplay of paradigmatic and narrative modes of thought. The findings support the argument of giving narrative stronger acknowledgement in science curricula and in science teachers' professional learning.

[27O4B-2] Differences in Pedagogical Content Knowledge between an Experienced Teacher and a Beginning Teacher through Implementing Argumentation-based Inquire (*A0223*)
Chih-Yu Tsai, Ko-Hui Lu*, and Kuo-Hua Wang+
National Changhua University of Education, Taiwan
ABSTRACT The purpose of this study was to investigate the differences in pedagogical content knowledge between an experienced teacher and a beginning teacher through implementing argumentation-based inquiry science teaching in middle school. A case study was used in this study. An experienced teacher (27 years teaching experiences) and a beginning teacher(less than one year teaching experience) were both invited as the subjects. Biology evolution was the observed teaching unit for the study. Classroom video-taping, semi-structured interview and checklist were used to collected data for analyzing and comparing pedagogical content knowledge of two case teachers. Results indicated that although the two teachers both knew about the theoretical of argumentation and inquire, agreed the needs to guide students learn argumentation by asking questions, to provided an opportunity for students to inquire science including not only the yes-no question but also reporting their arguments. Furthermore they all mentioned difficulties of implementation of argumentation-based inquire teaching, such as assessment and time restriction. Findings also showed that differences between two teachers, the experienced teacher believed objective of argumentation-based inquiry teaching should foster students' high-level thinking and scientific literacy, therefore she was able to use better pedagogical content knowledge to assist students in completing Toulmin's argumentation framework, but the beginning teacher could only guide students to make a claim without rebuttals and backings. Suggestions for science teaching and novice-expert teachers' research are provided in this study.

[27O4B-3] A Transmission of Science Education (*A0157*)

Kyouiti Sugiura*[+1], Shinya Ikeya[1], Takaya Tanaka[2], Yosuke Kominami[3], Kei-ichi Muraki[4], and Hitoshi Yamamoto[3]

1. Hamana Junior high school, 2. Hamamatsu Junior High School Attached to the Education Department of Shizuoka University, 3. Faculty of Education, Shizuoka University, and 4. Hamamatsu Gakuin University, Japan

ABSTRACT Previously, teachers in Hamamatsu Shizuoka Japan have made many creative teaching materials to utilize for classes. But, as time goes by people lose these teaching materials and the teaching methods because they aren't handed down to the next generation. We suppose that the teaching materials and the teaching methods rise from the dead and that we reactivate group-trainings for classes. For teachers, preparations for preliminary experiments, proficiencies in making materials, and teaching are the most important things. Teaching efficacy depends on the teaching material. On the other hand, Teachers are extremely busy with student counseling and guidance, and they have insufficient time to prepare for classes. In Japan we have training for newly hired university graduates and in-service teachers. In the training sessions, teachers learn how to conceptualize classes and to construct them. But the coverage of science is nature. We need to make students feel a sense of wonder in the eloquence of nature, and a sense of awe. It is essential to hand down information to the next generation to raise the ability of teachers. We make in-service teachers utilize our resources. In particular we are changing the proficiency of making materials, and teaching to PDF files. These files contain pictures and explanatory leaflets for utilization by in-service teachers at any time. We put the PDF files on a website. Additionally, we hold a training workshop by experts (two or three times in a term). We report the process to rise materials and methods from the dead. The characteristics and purpose of this research, and the expected results are as follows: 1 We define Junior-high school belonging to a university as a point of union between public junior high schools and university. This part is a significant property of this research. In the past, trainings of in-service teachers' science-education was active. We would aim to share the intellectual properties and to reactivate trainings of in-service teacher in cooperation with a university. 2 Teachers would seize back confidence of teaching and would care about one another through talking with daily distress. 3 The community-minded cooperation would offer a clear-cut answer for issues of in-service teachers.

<4C> Learners (Teaching/Learning)

Chair: Takuya Matsuura (Hiroshima University)

[27O4C-1] Integrating Musical Elements into Science Teaching to Explore Different Musical Intelligence and Naturalistic Intelligence Students' Science Learning Interests (*A0573*)

Chi-Hang Chang*[+] and Jing-Wen Lin

Department of Curriculum Design and Human Potentials Development, National Dong Hwa University, Taiwan

ABSTRACT The purposes of this study are integrating musical elements into science teaching to explore different musical intelligence and naturalistic intelligence students' science learning interests. And then, to understand the factors of students' science interests via classroom observations and interviews. This study adopted quasi-experimental design, and designed singing, tempo and music texture, three types of musical elements to integrate into science teaching. The topic, "plant propagation" was taken as an example. There were 95 grade 4 students participated in this study. Sixty four students were in the experimental group (integrating musical elements into science teaching), and 31 students were in the comparison group. After the multiple intelligence assessment, students in the experimental group were divided into four sub-groups: high musical intelligence and high naturalistic intelligence (6 students), high musical intelligence and low naturalistic intelligence (11 students), low high musical intelligence and naturalistic intelligence (12 students), and low musical intelligence and low naturalistic intelligence (16 students). The researcher used independent t-test to ensure whether there's difference between students'a interests in pre-test. And then, to detect pre-test post-test inspection of test data to "interesting in science learning", and to explore affecting the teaching of interests in learning. Continually, the researchers used Kruskal Wallis test to examine the significance of the progress of the former two questionnaires if there's significance on the progress of science learning interests from the inner group of four experimental sub-groups. Finally, the researcher understands the factors of influence of learning interests by classroom observation and interview. The results of this study are as follow: the results show that the musical elements are integrating into science teaching to enhance students' science learning interests, significantly better than the general teaching. The impact of the experimental sub-group and the control group learning effectiveness, factors musical elements - singing into such as "plant in addition to the use of seed propagation, can also use the roots, stems, leaves, etc. site to breed" the most significant science teaching. Speaking of learning interests, the four groups did not present significant differences. The interview can be learned by the student, regardless of the original musical intelligence and naturalistic intelligence performance, expressed this teaching becomes interest. Students with high musical intelligence are be able to say the feeling which of the elements are interested clearly. But students' with low musical intelligence which of the elements are interested. The answer is no feeling. In summary, as for the musical elements assimilate into science teaching, the empirical investigation has verified support. In addition, the researchers based on this analysis and characterization alignment presented the results obtained, advocates designed in this manner naturalistic science teaching, can indeed affect a wide range of student learning interests. Therefore, the researcher recommended that in addition to the aforementioned three musical elements, the instructor may try other musical elements into science teaching. And then, it is recommended to try exploratory study students from other kinds of intelligent performance, and this element into the field of science learning.

[27O4C-2] Students' Understanding of Three Levels of Chemical Representation on Dissociation of Strong and Weak Acids and Bases Concepts (*A0598*)

Navara Seetee*[1], Richard K. Coll[2], Manat Boonprakob[3], and Chanyah Dahsah[1]

1. Science Education Center, Srinakharinwirot University, Bangkok,

Thailand, 2. The University of South Pacific, Fiji, and 3. Behavioral Science Research Institute, Srinakharinwirot University, Bangkok, Thailand

ABSTRACT Chemical knowledge is related to three levels of representation—macroscopic, submicroscopic, and symbolic level—that combines to explain chemical phenomena. Many research studies suggest that students' ability to use and connect the three levels of representation is essential for understanding several chemistry concepts including acid-base. Additionally, acid-base is one chemistry topic considered as abstract and difficult to understand for high school students. Thus this study aims to explore students' understanding of the three levels of chemical representation on the dissociation of strong and weak acids and bases concepts. The research method is a qualitative research. The participants in this inquiry are 26 high school students from a classroom in Thailand. They were selected by convenience sampling from classroom that are studying on acid-base topic. The three level of chemical representation worksheet was used to collect the data on two main concepts: (1) the dissociation of strong and weak acids in water, and (2) the dissociation of water while adding strong acid and base. The data was analyzed using category analysis in three levels: sound understanding, partial understanding, and misunderstanding. It was found that students' understanding on macroscopic and symbolic level were at sound and partial understanding. While, students' understanding on the submicroscopic level was at partial understanding and misunderstanding. It indicated that submicroscopic level is difficult for students. Chemistry is the study of at particulate nature of matter, so that, submicroscopic level is one of the most important representation to get in-depth understanding in all chemistry concepts, especially acid-base. Therefore, teaching and learning chemistry for conceptual understanding should emphasis more on submicroscopic level, and also the connection between the three levels of chemical representation.

[27O4C-3] Relationship between Scientific Reasoning and Critical Thinking by using Decision Tree Model: The Theory of Buoyancy in Liquids (*A0607*)

Takuya Matsuura
Graduate School of Education, Hiroshima University, Japan

ABSTRACT Reasoning skills are major contributors to academic and everyday life success (Zeineddin & Abd-El-Khalick, 2010). The performance of scientific reasoning is influenced by scientific theory and/or prior knowledge (Zimmerman, 2000). So, previous study that administered to university students in Japan analyzed relationship between the theory of buoyancy in liquids (Archimedes' law) and scientific reasoning. Although they described the theory of buoyancy, some university students can't perform scientific reasoning well at the other context (Matsuura, 2014). On the other hand, Schraw et al. (2011) described four components of Higher Order Thinking Skills as follows: reasoning skills, argumentation skills, problem solving & critical thinking, metacognition. The purpose of this study is to investigate/explore relationship between scientific reasoning and critical thinking by using Decision Tree model (C5.0). The questionnaires and paper-test items about buoyancy in liquids based on the research of Zeineddin & Abd-El-Khalick (2010) were administered to 159 university students in Japan. The results of 111 students who had learned physics at high school showed the effect of carefulness and precision on reasoning performance.

[27O4C-4] Analysis of Elementary Students' Visualization Process of Creative Problem Solving in Science (*A0609*)

Jisoo Kim and Shinho Jang
Seoul National University of Education, Korea

ABSTRACT Cultivating creativity is one of the goals in Science education. Previous studies report that students use visualization while they solve the creative science problem and it looks helpful to make them think more. For this study Three 6thgraders were selected in the consideration of pre-test through the qualitative think-aloud method. They were also interviewed after their work. The results show that even though students have many ideas in planning stage in problem solving, they appeared to visualize familiar and empirical ideas at first. So if teacher want to watch another creative ideas, they tended to give enough time to visualize many ideas. Students drew lines, circles, "X"marks to select or remove information during their problem solving works. They said these marks seem to be useful to understand question. However, removal marks sometimes turn out to block another chance to rethink. Also students did not have a chance to reflect what they did. It means that they lose the chance to do convergent thinking. This means that reflection may be helpful for students' creative problem solving. Because In the process they could revise and improve their own ideas. But Elementary students' reflecting process did not appear often. The implications of this study include the importance of students' visualization works to facilitate their creative ideas and support their problem solving strategies. In this study, we discuss the meaningful messages for teachers who construct science classroom for creativity.

<4D> Teacher Education

Chair: Ying Zhou (Beijing Institute of Education)

[27O4D-1] The Training Models' Research of the Primary Science Teachers in Beijing Institute of Education (*A0251*)

Qi Kang*+ and Jing Li
College of Education, Capital Normal University and Beijing Institute of Education, China Mainland

ABSTRACT Due to the lack of practice and theoretic understanding of science knowledge, Science Process Skill and the pedagogy of science teaching, it was a challenge for most of the primary science teachers in China. Beijing Institute of Education is one of the most important in-service teacher training college in Beijing, China. The training team of primary science teacher in BJIE has set up different kinds of training models for different kinds of science teachers in different areas of Beijing according to the science education reform in China and around the world. The first in-service science teacher education undergraduate professional of Beijing was set up before 2000 and since then great changes about the science education had taken place in China and around the world and the faculty developed sorts of training models of the in-service science teachers in Beijing. The in-service

science teacher education has experienced a change in Beijing from 2008 to 2015. According to the needs of professional development of science teachers, We've developed different levels of training courses and formatted a complete series of training courses. 1. Initial teachers' training For the initial teachers, what they need is not the subject knowledge of science but how to arrange them. The theme of this kind of training is to improve the initial teachers' PCK, practice and research activities, and science class management as well. The main method is combined teaching with demonstration and practice. 2. Experienced teachers' training For the experienced teachers, what they need most is the new instructional theory and how to link the teaching practice to the theory and thus gain the sustainable professional development. Discussion and problem solving are the main forms of training. 3. Backbone teachers' training The training objective is to summarize the practical experience of teachers; the tacit knowledge into the knowledge can be spread. The main forms of training are the subject research, academic paper writing, teaching experience displaying, etc... In order to balance the development of education, we also set up a special rural teacher training courses. It focuses on the methods to carry out scientific education in rural areas with poor conditions. [Draft]

[27O4D-2] Learning-Program Development for Further Understanding of Radiation Risk (*A0265*)

Ayaka Maeda[1]*, Katsuo Sugita[2], Jun Nomura[2], Shoko Iida[2], Masaaki Iizuka[2], Beverley Horne[2], Kazuko Kita[3], and Tetsuya Kato[2]

1. Graduate School of Education, Chiba University, 2. Faculty of Education, Chiba University, and 3. Graduate School of Medicine, Chiba University, Japan

ABSTRACT After the Fukushima Daiichi Nuclear Power Station Accident in March 2011, various activities have been created to promote radiation education at school. For example, the Ministry of Education, Culture, Sports, Science and Technology has produced textbooks about radiation, and these were distributed to all schools in Japan. In 2008, with the revision of the government course guidelines for science, radiation education was introduced for the first time in 30 years. However, most people don't understand about radiation and continue to have a strong anxiety about radiation. In this study, we performed a knowledge investigation toward school teachers and developed some teaching materials based on the results. We examined the radiation knowledge of science teachers and yogo (school-health) teachers by using questionnaires. The targets of the surveys were 13 science teachers in high schools and 79 yogo teachers from elementary schools to the high schools. The contents of our survey were 15 items of influence on a human body of radiation and medical radiation. The percentage of correct answers was lower especially in some questions about the biological effects of radiation. The percentage of correct answers to question 2 (I have handled a mouse that became exposed to the fatal dose radiation, and then I became exposed to radiation) was 46.2% for science teachers, and 23.7% for yogo teachers. One of reasons seems to be the lack of appropriate materials related to radiation risk for these teachers. We have, therefore, developed a newer text focused on the biological effects of radiation in order to enhance their understanding of radiation. We took up some issues of low correctness of answers, and then created some learning materials to cope with the lack of knowledge using Power Point. These materials were illustrated with a lot of images and animations. As a way to visualize radiation which people can't see, we replaced it with a firefly. 'Radioactive material' was shown as 'the firefly of a body'; 'radiation' as 'light'; and 'radioactivity' as 'the ability to put out the light'. We were able to visualize invisible radiation. To deepen understanding of DNA repair, we performed the comet assay in cells after irradiation, and we have attached a cell image obtained from the results. These materials make teachers understand deeply the biological effects of radiation on the human body, which leads to fixing children's knowledge. Then by enabling the correct understanding of the radiation, people will be able to eliminate anxiety and live whilst thinking about each of the risks and benefits. We plan to determine the effect of using these teaching materials at some model schools.

[27O4D-3] Analysis of the Effects of University Students who Participated in Science Teacher Internship Abroad (*A0311*)

Jun Nomura[1,2]*+, Kyoko Yoshida[1], Yoshiaki Yamano[1], Sapto Asharadianto[1], Ryugo Oshima[1], Satoko Baba[1], Beverley Horne[1], Tomoyoshi Komiyama[1], Masaaki Iizuka[1], Yoshiya Itakura[1], Tetsuya Kato[1], Ryu Kinoshita[1], Shuji Shimonagata[1], Ken Shirakawa[1], Katsuo Sugita[1], Akira Takaki[1], Koji Tsuji[1], Yoshihiko Tsuruoka[1], Jun Nakazawa[1], Hideko Hayashi[1], Takeshi Fujita[1], Shuichi Yamashita[1], Masahide Yamato[1], and Chie Yoneda[1]

1. Faculty of Education, Chiba University and 2. Adachi City Yanaka Junior High School, Japan

ABSTRACT As a 'Super Global University', Chiba University is promoting various international educational programs for developing global human resources; one of them is the "Twin College Envoys Program" (TWINCLE Program). TWINCLE is an overseas teacher internship program in which students from education and science faculties are combined and work together to develop cutting-edge science teaching materials for conducting science experiment classes in ASEAN country's local schools, in collaboration with students of ASEAN country Universities. This program has been conducted for 4 years and 289 students deployed to ASEAN countries as teacher trainees. Based on student's 'experience' reflection post TWINCLE program, the effects of the program to students were evaluated for developing a better internship activity. In this research, we analyzed student's experiences through open-ended surveys using text mining. These surveys focus on the learning and growth experiences of students throughout the program while preparing the science classes over the course in one semester. The results showed that through TWINCLE activities, students were able to overcome various difficulties and able to acquire the skills to carry out activities in a global society. In addition, through this program students were able to experience intercultural exchange, teaching experience and growth by planning classes.

[27O4D-4] The Curriculum Development of Integrated Practice Activity in In-service Teachers' Training Based on STEM Education (*A0286*)

Ying Zhou
Beijing Institute of Education, China Mainland

ABSTRACT Currently, a flood tide of science curriculum reform seemed to portend integration and development at the stage of basic education. Integrated practice activity curriculum (IPAC) as a carrier of integration of different subjects (such as technique, engineering, and science) attracts more and more attention in recent years. Integrated practice activity curriculum which emphasizes experiential learning from practice is considered to be a light in Chinese curriculum reform. As the combination of academic study and practical experience, IPAC cultivates innovative spirit and practical ability. More and more schools in Beijing provide IPAC for their students; however the quality of curriculums varies. To encourage our students adapt the challenge of the 21th Century, IPAC are required to apply scientific concepts to design products or solve daily life problems. In China, as in the other countries, the national education department realizes that practice and application of what has been learnt is very important. Some cities, such as Beijing, have introduced policies that could entrench the IPAC hours and lesson arrangements. Though the curriculum reform in elementary education stage has already imposed in a high degree of expansion in China, there still exist some formalism and hypercorrection in IPAC. Thus, how to design IPAC development in in-service teacher training as to adapt to the demand of the new curriculum reform, is becoming an issue which needs to be resolved urgently. Based on the international comparison and the study on teaching activities, our group had developed 80 hours training to solve problems of the curriculum development of IPAC in middle school by drawing lessons from advanced education idea of STEM. More than 260 in-service science teachers from different schools in Beijing were involved in this training program. The main methods of the study are as follows: (1) Theoretical research based on literature research and the cross-region cooperation training from foreign trainers. Designing training courses which were expatiated on the basic strategies about the exploitation and utilization of IPAC recourses. The strategies were based on the categories of STEM education and the current situation in Chinese public schools. (2) Empirical study: (A) designing questionnaire and interview to survey in-service teachers and students in the base school as to test the teaching effectiveness of the existing IPAC.(B) making immersive IPAC training and teaching practice tracking measurement to help the in-service teachers to optimize the design of their own IPAC.)C) evaluating data accumulation. 3) Case study: collecting and refining IPAC case to share and promote excellent teaching experience. The educational products have also been developed base on case study, including the audio-visual publications and case-study teaching materials. 4) Case feedback: using empirical data and case analysis to optimize training courses and system. Through this research and training, in-service teachers' teaching behavior in design and conduct of IPAC have been influenced. Meanwhile, their international educational concept about STEM has been renewed. The study provides samples to the curriculum development of IPAC in in-service teacher training. The dissertation has received the subsidies of the major project of Beijing Institute of Education. (NO. JYZD201505)

<4E> ASTE Session 2
Chair: Yoshisuke Kumano (Shizuoka University)

[27O4E-1] Development of the Theories to Assess Students' Learning in a STEM Integrated Learning Environment (*A0522*)

Tomoki Saito*, Jin-Ichi Okumura+, Shoko Sakata+, and Yoshisuke Kumano+
Graduate School of Science & Technology, Shizuoka University, Japan

ABSTRACT In this presentation, the authors explain the theories for STEM Integrated Learning Environment (SILE) which is developed through their informal project "Shizuoka STEM Junior Project" from 2013. In addition, they provide an example of the appearance of SILE (Saito, Kumano, 2015; Saito, Anwari, Mutakinati, Kumano, 2016) to discuss future research in the assessment of STEM Education. The authors had constructed the theories to support the characteristics of learning in SILE. 1) The learning is not necessarily included in and assessed by standards for each discipline as in traditional classes; 2) learning within learners and across networks of learners has relationships beyond STEM disciplines, and 3) thus, the environment should be structured according to the vector of those relationships (Saito et al., 2016). In addition, the authors had revealed the appearances of those vectors by analyzing students' learning in SILE qualitatively and quantitatively. However, as the authors echo many times, these examples cannot be the grounded theory for the learning in SILE and/or lead to the systematic reform. Because if they intervene too much, the system of learning in SILE disappears and the students try to apply to the form which teachers expect. Thus, although these theories cannot be an idea which generalize the learning in SILE, the individual cases should be analyzed deeply. From these analyses, the authors have found some points for assessment. During their project, the authors gradually decreased their intervention to the students' learning. For example, at the early implementations, they provided proper engineering problem for the students. In the later implementations, however, they did not provided specific problems. These trials indicated that the students could define the engineering problem by themselves. The next point is to apply these STEM activities to the public school settings. In Japan, public schools have a course of study (national curriculum) and all of the schools have to adopt the contents standards and textbooks which are applied to the standards. In such setting, if the authors tried to apply STEM Education into public schools, they need to develop the possible assessment method and the application to the everyday implementation. The authors present the relationship with a first implementation in a public school by providing those theories and implementations may describe these points which are needed to apply to the practices in public school settings.

[27O4E-2] Status Study on STEM Education Development and Results from Shizuoka STEM Education Trials 2014-2015 and Future Setting (*A0520*)

Yoshisuke Kumano, Tomoki Saito, Jin-Ichi Okumura, Shoko Sakata, Naoko Kosaka, and Lely Mutakinati

Shizuoka University, Japan

ABSTRACT Status Study on STEM Education Development and Results from Shizuoka STEM Education Trials 2014-2015 and Future Setting Let me show my greatest appreciate for many countries and people who helped for the recovery of 3.11 natural disasters, so-called "Higashi Nippon Huge Earthquake Hazards" and the recovery of melt-down of Fukushima Nuclear Plants. After that natural and human-made disaster, the policy of Japanese Education System has been revised and main frameworks were conformed at the Central Education Council of Japan. One of the characteristics of Japan concerning to STEM is that government focused more on the innovation of STEM area, so-called Japan-innovation. Under the MEXT, you can find so many projects among scientists, engineers and technologists in all of the country. Especially, in order to break down all of the melt-down power plants, we need to develop high quality robotics which can work at the severe radiation environment for example. So many science & technology specialists in Japan are heavily understand the importance of STEM innovation; however, they are not realizing the importance of STEM education innovation in the K-16 education. So, in Japan there are a few task force institutions and researchers in the area of STEM or we can say that we are just starting the innovation of STEM learning. This year of 2016, there are about ten research groups who are in the research processes connected to STEM education with JSPS. Also, the institutions where STEM education center existed are only two universities; Saitama University and Tamagawa University. Shizuoka University got the grants for STEM education from JST for the second times and Shizuoka University is planning STEM innovation for graduate school courses. Shizuoka University has been working to develop workable model in the contexts of Japanese education for three years. What we have been investigating on STEM are (1) what is the nature of STEM education as the innovation of science education? : Theoretical analysis, (2) what are the major processes of three dimensional learning? : Practical analysis, (3) For the Japanese contexts for the innovation of science and technology, we need to develop unique theory and model needed for STEM learning in the informal education setting and formal education setting. We are finding the Next Generation Science Standards has direct connection with STEM education innovation. We would like to develop evidences that STEM education can develop well in terms of 21st century skills or competencies. [Draft]

[27O4E-3] An Action-Research on the Expansion of the Biological Knowledge and Achievement of the Scientific and Engineering Processes at the High School Students in the Learning of the Avian Embryonic Experiment based on Bio-STEM Perspective (*A0353*)

Jin-Ichi Okumura*, Tomoki Saito[+], and Yoshisuke Kumano[+]
Shizuoka University, Japan

ABSTRACT According to the course of study for high school biology in Japan, the purpose of study is to develop inquiry ability and positive attitudes toward science through experiments and observations. However, because of their access to the virtual world, modern high school students have had less contact with nature in their childhood. Therefore, biological concepts are hard for them to understand concretely. So, in science classes, they could not see the relevance of living things and biological phenomena. There were many high school students who could not believe egg embryos could become fully hatched birds with only a 34- or 46- hour incubation period, as described in an experiment from a commonly used high school textbook, even with careful observation. That was why we developed lesson plans not only to observe avian embryos, but also to continue incubation until the eggs hatched. We also made students study about egg incubation methods themselves using STEM ideas in biology (Bio-STEM). When the embryos did not develop into chicks, most of the students were eager to try the experiment again. They designed and made two types of artificial incubators to solve the problems presented by the textbook designs and tried to incubate eggs again with their own incubators. The second time, the students finally worked out how to get a chick using their own machine. As a result of designing and making the artificial incubators, the students generated many ideas connected to the STEM fields deepened their cross-cutting scientific thoughts. For example, students chose the motor which became the appropriate speed for egg rotation. Importantly, students were able to experience the wonder of life in a real and concrete way. Through their experiences in Bio-STEM, the students were encouraged to form scientific and technological minds and attitudes.

[27O4E-4] STEM Education for the Development of School Entrepreneurship: The Pilot Project in Thai Schools (*A0346*)

Suparabhorn Subongkoj
The Institute for the Promotion of Teaching Science and Technology (IPST), Thailand

ABSTRACT In the driving of K-12 STEM education in Thailand, we have faced with difficulties of how to efficiently implement STEM in the diverse socio-economic backgrounds of students. Particularly, when the implementation taken place in schools, serving students from lower income families who are unlikely to continue their education after compulsory education which is grade 9 in Thailand. These students are likely to work as low skilled labors in job markets. It seems the centrally designed STEM activities can not engage students to the full expectation. To engage students from diverse socio-economic background, the activities must be contextually suitable to their school settings and enhance their livelihood. Therefore, we launch the STEM Education for School Entrepreneurship Development pilot project. The aims of the project are 1) To engage students in various socio-economic backgrounds. 2) To engage students to utilize their STEM content based-knowledge by developing the products to sell. The students have to create the business plans on how to sell their products after they have identified what problems they would like to solve and what products they think will solve the problems. 3) To inform students about different career opportunities. This will open their options whether they want to continue in higher education, vocational schools or work. 4) To prepare high quality workforce for the highly competitive future job market. In the pilot project, 5 schools have been selected by IPST and 30 of grade 9 -12 students are selected by the schools as the leaders in their demo-companies to join E2STEM camp. Then, after 2 months the students will join trade fair and competition. We aim that the students will be more aware of their career opportunity and gain higher

STEM literacy. Moreover, they will achieve the 21st century skill proficiency (communication, critical thinking, technology, financial literacy, etc.). These skills will enhance them to be more competitive particularly in the emergence of the ASEAN Economic Community.

<4F> Historical/Philosophical/Sociological/Cultural/Gender Issues

Chair: Eugene Kang (Pusan National University)

[27O4F-1] On the Historical Development and the Pluralistic Approach for the Concept of Electricity in Secondary-school Science (*A0113*)

Eugene Kang

Pusan National University, Korea

ABSTRACT Previous research on the historical development of the concept of electricity in the secondary science focused on teaching-learning programs for enhancing the understanding of key concepts and problem-solving ability. These teaching-learning programs tried to remove or decrease the past concepts and enhance the current scientific concepts. They premised that scientific concepts were developed by linear accumulations, such as from the fluid of electricity to the particle and the field. However, past concepts are still valid for explaining various characters of electricity. The fluid concept, which is criticized as a misconception in science education, was from Maxwell's and Thomson's theories and explanations, which are still important in current science. It is, for example, still valid for explaining the conservation of charges to young students. The particle concept is also valid, for Coulomb's law and Thomson's electron. Past scientific concepts seem to cause misconceptions, to make students confused, and to be responsible for inconsistence of textbooks. This is not because of past concepts themselves but because of the way in which scientific development is typically viewed. The view of linear accumulations do not reflect the authentic development of science, nor give consistency to science education. Then I suggest 'the enduring concepts' including both the present scientific concepts and the past scientific concepts which are valid for explaining in science textbooks.

[27O4F-2] Routes of Secondary-school Science Textbooks from Western Countries to Korea via Japan and China in Late 19th and Early 20th Centuries (*A0114*)

Eugene Kang

Pusan National University, Korea

ABSTRACT Many schools have since 1883 been founded by Koreans and foreigners to enlighten Korean pupils and enhance their abilities. According to official government documents, there were 2,237 schools including 1,282 private schools, 755 missionary schools, and 82 government schools in 1910. School founders and heads thought the most important knowledge from Western civilisation was science and technology. They tried to teach western science and technology with various materials. After 1910 when Korea was forced to be Japanese colony, most curricula in Korean schools were controlled by the Japanese government. This is why only Japanese textbooks and materials for science education were adopted in schools after 1910. Before 1910, various sources were used in Korean schools. According to government documents for school textbooks, 138 science textbooks were approved by the Minister of Education from 1895 to 1915 (Park, et al., 1998). Most schools adopted science textbooks in Korean or classical Chinese, while some missionary schools adopted science textbooks in English. Authors and editors of textbooks were Koreans, Japanese, Chinese, and western. 62 of 138 textbooks were published in Korean territory, and 38 authors were Korean. Science textbook writers were not specialists in science education (Park and Chung, 2000). Japan was the most important country to influence Korean science education in the 19th and 20th centuries. Many authors of science textbooks studied in Japan. Previous research has shown what science textbooks were used in Korean schools and who wrote and published these in the late 19th and early 20th centuries. However, these studies just focused on Korean authors and Korean territory. Science textbooks written by Koreans in the 19th century had to be influenced by western knowledge. Only Japanese influence was clearly acknowledged. There were three possible routes. One was from western countries via Japan, according to previous research. Another was be the direct route from western countries. Missionaries could play an important role in this enterprise. The third route was from western countries via China. Before the first Sino-Japanese war in 1894, Korea was strongly influenced by China. As Korean intellectuals were familiar with Chinese literature, they might read science books from China rather than other countries and were influenced before 1894.

[27O4F-3] Physics Education in Japan in the Middle of Meiji Era Effected by Worldwide Science Educational Innovation Based on Analysis of Normal School Students' Notes (*A0296*)

Fumiko Okiharu*+, Akizo Kobayashi, and Keisuke Kamimura

Niigata University, Japan

ABSTRACT We have investigated the new aspects of historical physics education studies based on analysis of various students notes in the middle Meiji Era1). These students' notes reveal realities of physics lessons at that time where we could not verify from laws and textbooks. These notes' data are collected from all over Japan, and these notes were written by various school students from elementary schools to normal schools (teachers colleges) in Meiji era. In this presentation, we show how normal school students studied physics with high-quality contents in the middle Meiji era. They studied predigested educational contents in addition to imported textbooks. In those days, science education was innovated all over the world, for example, Christmas lectures at the Royal Institution of Great Britain were already started since 1825, the science education studies were conducted across the United State around 18802). In Japan, science education was initially imported after opening the country. After decades, science education continuing today had been established in the middle of Meiji Era. We report what type of physics education had been performed at the real normal school with reference to world trends on those science educational innovations.

[27O4F-4] The CHAT Analysis of Korean Science Teachers' Volunteer Service in Timor-Leste (*A0217*)

Sungmin Im* and JaeYoung Han+
Daegu University and Chungbuk National University, Korea

ABSTRACT Timor-Leste is a newly-independent nation and one of the poorest countries in the world. Many advanced countries or NGOs have provided various aids to help Timor-Leste develop. Korean science teachers have been offering voluntary services in Timor-Leste since 2004. This study aims to analyze this voluntary activity with the Cultural Historical Activity Theory (CHAT). The CHAT analysis, which includes six component of an activity system such as subject, object, tools, rules, community, and division of labor, can be used as a tool to understand human activity by revealing the whole structure of an activity and conflicts within activity or between activity systems. We interviewed several participants of the voluntary service including the teacher who visited Timor-Leste for the first time. In 2004 the teacher visited Timor-Leste alone, but now about 15 teachers visit together. We could find many changes in the activities of voluntary service, such as the increase of subject, the change of object, the development of tools, the refinement of rules and division of labor, and the formation of community. The voluntary service have been developed both in quantitative and qualitative aspects.

<4H> Mathematics Education

Chair: Meichun Lydia Wen (National Changhua University of Education)

[27O4H-1] The Eye-Movement Behavior of Proof Validation in Abstract Algebra (*A0225*)

Wei-Yang Chen* and Meichun Lydia Wen+
Graduate Institute of Science Education, National Changhua University of Education, Taiwan

ABSTRACT Proof validation, which is important to the teaching and learning of mathematics, is the process that one makes a judgement on a given proof, and one needs to judge if this proof is valid or invalid. From the literature review, we found that proof validation experiences are important for students because they can help their understanding of major concepts in mathematics, especially for those pre-service mathematics teachers who will teach related subjects in the future. To investigate the differences in proof validation process between more and less experienced participants, recent researchers utilize the advantages of eye-tracking technology to understand the detailed information of reading process while participants validate proofs. In our preliminary study, we designed an eye-movement experiment to analyze the behaviors of proof validation between the more and less experienced participants. We invited six volunteered undergraduate or graduate students with a major in mathematics, who were also pre-service teachers, and there were 2 males and 4 females with an average age of 22.67. Three of them were categorized as the more experienced group because of extra tutor or teaching experiences. The participants were interviewed before the eye-tracking experiment about personal information and experiences. In our eye-tracking experiment we designed 4 Abstract Algebra proof validation tasks/problems, and every task/problem consisted of a question and subsequent proofs which may be valid or invalid. Then they were interviewed again about the validation processes they have just completed. The results of our preliminary study were, first, we found that the more experienced participants would make less saccades between the question area and proof area during the whole reading process. Second, from their scan-path data, we found that when the less experienced participants read the proof area, they frequently checked the question area in almost every problem, while the more experienced participants rarely checked the question area when they read the proof area in every problem. More specifically, almost in every problem, the less experienced participants usually read the very first line of proof then regressed back to the question area. Last, the gaze duration of the question area for less experienced ones was less than 10% of their total reading time in 3 of the 4 problems, but it was more than 10% for more experienced ones. We also analyzed the proof validation types of each problem based on eye-movement data and found that even the more experienced group might neglect certain details in proof area. Based on our results, we concluded that there were certain different behaviors of proof validation process between the more and the less experienced participants, and our study helps educators in mathematics to better design the proof validation process. In the future work, we will invite more participants, and add validation tasks of counterexamples because proof validation and counterexample validation are both used in logical thinking, and together we hope our work can add value to how to teach proof validation more efficiently.

[27O4H-2] Flipped Teaching Approach in College Algebra: Cognitive and Non-cognitive Gains (*A0178*)

Maxima J. Acelajado
De La Salle University-Manila, The Philippines

ABSTRACT This study looked into the cognitive and noncognitive gains from using the flipped teaching approach (FTA) by comparing it with the traditional classroom approach (TCA) in four topics in College Algebra which were identified as difficult, namely: Factoring, Rational Expressions, Operations on Radicals and Solving Applied Problems. Two intact classes of 24 (Group 1) and 31 (Group 2) freshman education majors of De La Salle University-Manila enrolled in College Algebra during the First Term, SY2014-2015, served as respondents of this study. This study utilized a quasi-experimental design with switching replication: the group exposed to FTA was considered the experimental group and the group exposed to TCA, the control group. Group 1 served as the experimental group in the first two topics and Group 2, in the last two topics. A validated teacher-made pretest/posttest was administered to both groups to gauge and compare their achievements in each topic considered in this study. To identify the noncognitive gains of the students from using the FTA, they were asked to write journals and answer a perceptions inventory related to the use of the flipped teaching approach. The flipped teaching approach was done by giving the respondents the opportunity to learn, by themselves, the above-mentioned topics in College Algebra online prior to coming to class. and what used to be the homework/assignment was done in class with the teacher offering more personalized guidance and interaction with students, instead of lecturing. On the other hand, the students exposed to the traditional

classroom approach learned from the lectures and class activities provided by the teacher based on the prescribed textbook. At the start of the experiment, the experimental group was provided with the syllabus and the list of all websites, videos, powerpoint presentations, lecture notes and modules that they need to watch/read and the assessment materials to be completed while doing the online activities. During the face-to-face class time, they were given more interactive activities which were done either individually or in groups with the teacher acting as facilitator. The control group was taught exactly the same topics following the same syllabus and was given the same activities in class after which the students were given the assignment/homework for submission during the next meeting. Findings indicate cognitive gains such as improved critical thinking ability and achievement in each topic and noncognitive gains such as confidence, persistence, improvement of attitudes toward mathematics, greater motivation and cooperation among students.

[27O4H-3] Proposed Learning Support Model Using the Reflection Sheet in Secondary Mathematics Education: Attention to Meta-learning Skills (*A0298*)

Naoki Enomoto*, Yuki Watanabe, and Minoru Itoh

Graduate School of Mathematics and Science Education, Tokyo University of Science, Japan

ABSTRACT This study is focused on developing support system based on meta-learning skills, using the review test of the regular mathematics exam. The survey was conducted to 125 students in the public junior high school in Tokyo. The review test is designed similar to the regular exam. The test was given after two weeks of the regular exam last June 2015. Then, the learners were categorized into four types to support their meta-learning skills. Enomoto (2015) categorized four learning types to support student's learning. The scores of exam and meta-learning skills, taken by Reflection Sheet, are normally distributed having each term exam score as Z and the meta-learning skill as M. The 4 types of learning appeared as follows. Type I scored high in both exam and meta-learning skills (Z>0, M>0). Type II scored high in exam but low in meta-learning skills (Z>0, M<0). Type III scored low in the exam but high in the meta-learning skills (Z<0, M>0). Type IV scored low both in the exam and the meta-learning skills (Z<0, M<0). Therefore, when this learning support system for learners will work, learners will be considered for the improvement of scores in regular mathematics exam. Comparative test was performed to know if the target low learner performs better than the average point at regular exam (Z<0). Results showed a significant increase compared with the average score of the review test than the regular exam. Hence, when some learners got the learning support system for meta-learning skills, they improve their score in the regular mathematics exam. This result opened up for suggesting the new method for study support based on study types.

[27O4H-4] Eye-movement Analysis while Solving Force Concept Inventory: A Comparative Study between Japan and Poland (*A0243*)

Eizo Ohno[1]*[+], Roman Rosiek[2], Miroslawa Sajka[2], Michiru Iwata[1], and Atsushi Shimojo[1]

1. Hokkaido University, Japan, and 2. Pedagogical University of Cracow, Poland

ABSTRACT Eye-movements of Japanese and Polish university students while solving basic physics problems are analyzed using eye-tracking equipment. In this study, the authors tried to make a comparative study of the relation between students' problem solving strategies and physiological data from their eye-movements. Tobii T120 and SMI 1250 Eyetrackers were used for eye tracking. These are table-mounted systems. The physics problems were selected from the Force Concept Inventory. The experimental procedure was as follows. The problems were displayed on a computer screen, placed in front of the participants, one by one. The participants (eleven Japanese and thirteen Polish university students) were asked to read and solve the problem silently, and say the answer aloud when they have solved the problem and chosen one option. His or her eye-movements were recorded while they read, solve, and answer the problem. After the measurement, each participant was interviewed about his or her problem solving strategies. Every interview consisted of the following five questions: 1) Why did you choose your answer? 2) Did you have any confusion over terms and illustrations, etc? 3) Was the illustration helpful? 4) Was there any second candidate? 5) If you scale one as easy and five as difficult, how would you rate this question? We use three indices for the analysis of eye-movement data: total fixation duration, observation counts, maximum observation length (fixation). By using the indices, the authors evaluate whether the participant had an idea on how to solve the problem, even if it was based on a misconception, or was at a loss while trying to solve the problem. Students' misunderstanding on the basic concepts of Newtonian mechanics and problem solving strategies are considered using two data: qualitative data from the interview, and physiological data from the eye-movement. In this comparative study, we focus on the following problem. A hockey puck sliding with constant speed on a frictionless surface is received a kick. A student chooses which of five paths (option A to E) the pack follows after receiving the kick. In our measurement, many Japanese participants tended to choose a straight path (the correct option B) than Polish participants. Many of the Japanese participants who chose option B told in the interview that a constant force is always exerted on the hockey pack to keep it sliding with constant speed. Further, we found out that they used a triangular force diagram, which they had learned at junior high school and/or high school, to solve the problem. They added a force exerted by kicking on the constant force. For the Japanese participants who chose option B based on the misconception, the maximum values of the three indices corresponded to option B. For the participants who were at a loss, maximum values of the indices don't show the participants' choice clearly. We consider that the misconception described above is derived from the Japanese participants' school education. In this presentation, we also show the results on Polish participants. Different characteristics appeared in their response tendency. We consider some possible reasons for this difference by comparing science curricula and instructions of both countries.

<4I> Curriculum/Assessment/Policy (Curriculum/Teaching Materials)

Chair: Manabu Sumida (Ehime University)

[27O4I-1] Evaluation of 'Science Project Research' as a Subject in Japan's Super Science High Schools (*A0437*)

Yuki Ozawa[1]* and Manabu Sumida[2+]

1. Graduate School of Education, Ehime University* and 2. Faculty of Education, Ehime University, Japan

ABSTRACT In Japan, the Super Science High School (SSH) project began in 2002. The program's mission is to designate certain senior high schools that will implement pioneering mathematics and science curricula to train global human resources of the future. As its scope has expanded year by year, the program has increased the base of science and technology personnel. As of 2015, 203 schools had participated in the program. The new course of study for high school science includes a proposal for a new subject known as 'Science Project Research'; its aims are to enable students to identify scientific issues and plan and conduct a science project either individually or collaboratively. This subject would promote creativity and develop skills and approaches toward scientific inquiry through a series of inquiry-based science project research activities. The goal of the present study is to analyse the evaluation methods of Science Project Research as an offering in SSHs. A total of 163 year report of SSH in 2014 was analysed for its criteria and methods of evaluation of the science project research. Results showed that 81 schools used only simple questionnaires or self-evaluations to evaluate science project researches. Thirteen high schools conducted a paper/pencil test based on the Programme for International Student Assessment (PISA) study. In 27 schools, rubrics had been developed, but 12 of these used their rubrics only for summative assessments. Furthermore, none of these schools arbitrated regarding applications of rubrics by teachers and students. It can be concluded that the development of evaluation methods with high degrees of validity and efficiency is an imperative need if Science Project Research is to be implemented broadly in Japanese high schools. A formative assessment will also be recommended for students to recognize their progress and enhance self-efficacy.

[27O4I-2] Exploration on the Construction of Science Teaching Quality Monitoring System in Minority Areas of China (*A0289*)

Liao Boqin

Center for Studies of Education and Psychology of Minorities in Southwest China, Southwest University and The Research Center for Science Education, Southwestern University, China Mainland

ABSTRACT The construction of teaching quality monitoring system relates to the effectiveness of teaching quality monitoring. Different evaluation purposes determine the different evaluation framework. The science teaching quality monitoring in primary and secondary schools of minority areas is to understand the situation of science teaching, to analyze the influencing factors of teaching quality, to monitor the teaching development, and to provide a reference as the national education decision. Based on the comparative analysis of PISA, TIMSS, NAEP, NAEQ, according to the national standard of science curriculum, the science teaching quality monitoring system in the minority areas is constructed from horizontal dimension, such as the scientific concept, scientific thinking, scientific inquiry and scientific attitude, and from vertical dimension such as the complex of tasks and the situation of novelty, which divide above four dimensions in high, middle, low three levels. The complexity of the task and the situation of novelty can reflect the minorities' character through integration of curriculum resources in the monitoring system. [Draft]

[27O4I-3] The iHarris Academy Science-based Curriculum for Nurturing Gifted Potentials of Young Filipino Children (*A0382*)

Greg Tabios Pawilen

Harris Memorial College, The Philippines

ABSTRACT For centuries, science has nurtured and produced many gifted individuals across different cultures around the world. In the context of young children, science has always been an interesting field and subject providing opportunities for children to observe, discover, explore, experiment, and solve problems related to the physical and the natural world. It is also important to recognize that many young children are born with gifted potentials in science. This paper focuses on the iHarris Academy science-based curriculum, which is a pioneering work in the Philippines that offers a unique curriculum, which aims to develop the gifted potentials of young Filipino children in science. The Academy got its inspiration from the Kids Science Academy established by Dr. Sumida Manabu, a Japanese scholar from Ehime University. This paper has three parts: (1) the development of the science-based curriculum for developing gifted potentials of young children from ages five to eight, in science, (2) the contents of the curriculum, and (3) the implementation of the curriculum. The curriculum is uniquely special as it utilizes indigenous materials available in the community and addresses issues and problems based on Philippine context. The science-based curriculum of the iHarris Academy is an innovation that aims to inspire more schools in the Philippines to develop a special curriculum for young children with gifted potentials in science.

<4J> Communication/Engagement

Chair: Jianlan Wang (Texas Tech University)

[27O4J-1] Scrutinizing the Positions of Students and Teacher Engaged in Argumentation in a High School Physics Classroom (*A0306*)

Jianlan Wang* and Gayle A. Buck[+]

Texas Tech University and Indiana University, USA

ABSTRACT Despite the importance of argumentation, it rarely occurs in science classrooms. There exists a gap between the theoretical importance of argumentation and its practical insufficiency in classrooms. Researchers have tried strategies to bridge this gap but these efforts have limited and short-term impacts on transforming existing classroom practices. Argumentation is a linguistically social interaction. It is necessary to go beyond understanding the input and output of argumentation and comprehend the interactive process of argumentation. In this case study, our focus dealt with understanding how a physics class in the US adapt argumentation. We used the positioning method to gauge the relational process of argumentation in a high

school physics classroom. The participants were one high school physics teacher and his College Prepatory (CP) physics class. The teacher had 25-years experiences teaching physics. Among the 23 students in that class, there were two 10th graders, eighteen 11th graders, and three 12th graders. The physics content involved was classic mechanics, including Newton's three laws, momentum, mechanical energy, simple machines, and centripetal force. Through scrutinizing the positions of the participants in class for 6 months, we closely examined the ways in which individual variation resulted in classroom communities adopting and evolving the argumentative practices. After summarizing the patterns of positions that stood out, we constructed a dynamic model of argumentation. With this model, we analyzed how argumentative practices were impacted by the inner factor in terms of students' academic background and the outer factor in terms of argumentation context. Finally, we made suggestions on the implementation of argumentation in high school science classes.

[27O4J-2] Taiwan Students' Engagement in Science: Analysis of Data from PISA 2006 and 2015 Field Trial Test (*A0212*)

Ya-Chun Chen* and Huann-Shyang Lin+
National Sun Yat-sen University, Taiwan

ABSTRACT The purpose of this study was to examine and compare the differences of students' engagement in science for 15 years old students in Taiwan. The two datasets were accessed from PISA 2006 (N=8,815) and PISA 2015 Field Trail test (FT) (N=2,661) national databases for Taiwan. The measures of students' engagement in science contain three aspects: (1) cognitive engagement including self-efficacy in science and science self-concept; (2) emotional engagement including enjoyment of science and interest in science subjects; (3) behavior engagement including science activities participation in leisure time. The results of secondary analysis reveal that students' self-efficacy in science, enjoyment of science and interest in science subjects on PISA 2006 (means are 23.08, 12.94, 13.76, respectively) are significantly better than PISA 2015FT (means are 22.45, 11.84, 12.90, respectively), p value <0.01. However, students' self-concept and out of school activities on PISA 2006 (means are 13.74, 9.29, respectively) and PISA 2015FT (means are 13.88, 9.35, respectively) are not significantly different. Our findings indicate that students' engagement in science has shown the decline in many aspects. For example, the proportion of students' interests in learning about science subjects are decreased in physics, chemistry, biology, and astronomy, except for geology. Based on these findings, suggestions and implications in science education are addressed.

[27O4J-3] Growing Future Citizens who Survives Scientific/Technological Society based on "Regulatory Science" (*A0554*)

Midori Takahashi*+, Yuji Takagi, and Kazunori Uchino
Shizuoka Kita High School, Japan

ABSTRACT Many of the issues which arise in the course of the interaction between science or technology and society hang on the answers to questions which can be asked science and yet, which cannot be answered by science (Weinberg, 1972). Current society represents the same situation, having the issues that need to be solved but in a more complicated social structure where diverse stakeholders exist. People needs to take a more positive role in order to enjoy the fruits of science and technology to sustain safety and ease. Thus they need to engage more positively in discussion/deliberation with acquiring sufficient knowledge and scientific thinking. The knowledge and scientific thinking in this context includes the idea of called "regulatory science," which is referred to as the one that determines regulation and criteria to represent safety of scientific and technological products. This idea requires evaluation and judgment of the products to adjust them so that they fit to people and the society in a better manner. This idea is especially necessary for teenagers who will hold the control in the future society. However, little of this has been discussed in the discipline of science communication or almost no attempts has been made to educate people from this perspective. A science project was administered in an international science forum where 100 high school students from 8 countries got together and discussed about the desirable state of science and technology. The participating students evaluated and made judgment the present fruits of them and thought about the new criteria based on the data collected as well as the social circumstances around the theme. The students made a report modeling upon Intended Nationally Determined Contributions that were created by the countries attending COP21. The project also provided an opportunity for the students to discuss with the professionals of science and science communication on what they have created. The success and the future implications of this project will be reported from the viewpoint of what the students have learned, how effectively discussion with the professionals worked, and what action the students would take afterwards based on what they have created. The implication toward educational design of this project will also be reported.

[27O4J-4] "Unless you can explain it to your grandmother": Voices from Graduate Students and their Professor Regarding the Importance of Science Communication Courses (*A0226*)

Nadi Suprapto*+, Huei-Hsuan Lin, Chih-Hsiung Ku, and Te-Sheng Chang
National Dong Hwa University, Taiwan

ABSTRACT Using qualitative methods of research, the study aimed to analyze the experiences of graduate students and their Professor deals with science communication courses and the hot issues around them. The course consisted of two themes: social cognition and science communication. In this study, four graduate students and one Professor of science education program at National Dong Hwa University (NDHU) Taiwan submitted participant interviews to discuss their learning experiences in the science communication courses. Participants have various background factors that have been included, such as, graduate, gender, age, and ethnicity. The findings indicated that, first, the participants argued that science communication courses represent the relationship among science, technology and society (STS) and socio-scientific issues (SSI). Science communication bridges the gap between people and science communities. Second, the essential learning experiences can be captured from science communication courses included some dimensions:

instructional design, media and technology, classroom management, interpersonal interaction, and assessment. Third, the hot issue around science communication can be classified into science content, nature of science, and the role of social cognition theory. Furthermore, weather forecasting, earthquake, STEM (science-technology-engineering-mathematics) education, climate change, biotechnology, nanotechnology, environmental conservation, nuclear power, and some issues in daily life were some hot contents behind science communication.

<4K> Teachers (Teacher Education)
Chair: Cedric Mpaso (Hiroshima University)

[27O4K-1] A Conceptual Model for Understanding How PCK changes in Science Teachers (*A0128*)

J. Steve Oliver and Soonhye Park
The University of Georgia and North Carolina State University, USA

ABSTRACT Over the past 30 years, a great deal of educational research has been conducted to create and deepen understanding of pedagogical content knowledge (PCK). This body of research has provided descriptions and analyses of how teachers enact and amalgamate their knowledge of pedagogy, subject matter content and context into what Shulman labeled as PCK. The authors of the current proposal have put forward models of PCK that build on the work on Shulman, Magnusson and others to suggest that PCK can be described within five or six major components of the expert science teachers' knowledge. Further, these models are built on evidence that reflection is the driving force in the growth of teachers' knowledge parsed within those components. Reflection on teaching is often a planned activity that is guided. But what can be said about the role of stimuli, events, or incidents that serve to initiate reflection that happens spontaneously? In this paper, we put forward a conceptual model of the initiation of reflection based on the teachers' recognition of "distinctiveness" among the stimuli, events or incidents of their science classroom instruction. Distinctiveness is defined for this purpose as the original recognition of similarities and/or differences among the activities, actions, curricula, explanations, responses, statements, questions, etc. that occur within the science lesson. Drawing on the literature of science education and educational psychology, the presentation will describe how the insight of distinctiveness combined with metacognitive transformation of knowledge can be used to explain change in teacher knowledge. The argument presented in the paper will be based on both a synthesis of existing literature and the evidence gleaned from re-analysis of our on-going research into science teachers PCK. This paper will be of interest to all science educators who conduct research into teacher knowledge or who conduct teacher education for pre-service and in-service teachers.

[27O4K-2] Handling Experimental Data in Science Inquiry: Examining Teachers' "Thinking behind the Doing" (*A0130*)

Md Shahrin K S Moorthy
Academy of Singapore Teachers, Ministry of Education, Singapore

ABSTRACT The main way the goals of science education in Singapore will be realized is through science inquiry. This is often achieved through science investigations in which teachers are asked to go beyond presenting facts and outcomes, the "what (content)", and develop the "how (process)" of science (Ministry of Education, MOE, 2014, p.13). In other words, students' conceptual understanding of scientific laws and theory should be developed by actively engaging them with experimental data gathered during science investigation activities. Besides collecting, analyzing, processing, and interpreting experimental data, students should also be taught and guided to evaluate data in terms of reliability and validity in order to make good procedural decisions during an investigation and reach certain conclusions or findings. Invariably, the development of such knowledge and skills in students will be impacted by their own teachers' understandings of handling data and their ideas about reliability and validity in the investigation processes (Roberts and Johnson, 2015). Such a notion gains even more significance if we consider the fact that science teachers are expected to take on the role of a "leader of inquiry" and "facilitate and role-model the inquiry process" (MOE, 2014, p.2). The study that will be reported here only focuses on pre-service primary science teachers' understanding of reliability and validity in planning an investigation and in the interpretation of data in order to make the right procedural decisions. The data used in the presentation were derived from a qualitative study consisting of a questionnaire and two separate interviews conducted with fifty-five pre-service teachers. The findings will show that a significant number of these pre-service teachers did not have a good understanding of both planning investigations and interpreting data. The gaps of knowledge could be due to a lack of deep understanding about the "thinking behind the doing" of certain procedural actions as well as the entrenchment of alternative conceptions in some procedural steps taken during investigations (Roberts and Johnson, 2015). Possible reasons for these findings will be discussed. The findings reported here will have strong implications in the design and content of workshops and training courses for both pre-service and in-service teachers especially in the light of reforms that are taking place in the science practical curricula and laboratory-based assessments.

[27O4K-3] Perception of Science Teachers' on Student Centered Learning Following their Attendance to Continuous Professional Development (CPD) Trainings: A Case Study of Strengthening of Mathematics and Science in Secondary Education (SMASSE) INSET Malawi (*A0393*)

Cedric Mpaso and Kinya Shimizu
Graduate School for International Development and Cooperation, Hiroshima University, Japan

ABSTRACT Despite a series of trainings offered by the Ministry of Education, Science and Technology (MoEST) to update its secondary school mathematics and science teachers on pedagogy in order to improve teaching and learning of these subjects, observation has shown that teachers are still facing challenges in implementing student centered pedagogy. Further to this, MoEST has just revised the secondary school curriculum in which student centered pedagogy is highly emphasized as the best pedagogy to be used. This study is therefore aimed at soliciting science teachers' views on the students' centred lesson implementation through activity, student, experiment, and improvisation (ASEI) and plan, do, see, and improve (PDSI)

approach as opposed to the traditional way of teaching which is characterized by chalk and talk (MoEST, SMASSE Project Document:2004, p11). Student centered pedagogy is based on constructivist learning theory which emphasizes on students playing an active role in a lesson and teachers as facilitators of learning process. Such lessons also equip students with a scientific approach to understanding phenomena as a way acquisition of knowledge, lifelong learning skills and problem-solving strategy. Guskey (2002) found out that teachers tend to abandon new practices learnt during continuous professional development trainings if there is no evidence of their positive effect hence need to have better ways of providing feedback. To ensure that teachers are implementing what they learnt through CPD, continued follow-up, support and pressure to teachers after their CPD training should not be an optional for improved student learning in schools (Guskey (2002); Whitehouse (2011)). However, Loucks-Horsley, et al. (1987) in Guskey (2002) has clearly stipulated that any successful teacher professional development should be seen as a process and not one-time event. The findings from this study are expected to inform better practices in CPD provision and to education administrators on evaluation of revised curriculum against teachers' pedagogical content and knowledge. A mixed method research design will be used in order to capture both qualitative and quantitative data. A questionnaire shall be administered to a sample of science teachers that have been attending INSETs for at least three times from schools within catchment area of six INSET centers (of the eighteen INSET Centers country wide representing 33.3%). Thereafter interviews and lesson observations shall be conducted to a sample of teachers selected purposefully from above-mentioned population in order to capture their perceptions through practice. Results shall be analyzed using Statistical Package for Social Sciences to determine the cause and effects. The findings shall be related with qualitative data collected through interviews and lesson observations to make final conclusion for the study.

<4L> Teaching/Learning (Teacher Education)
Chair: Yuxuan Xiang (Beijing Normal University)

[27O4L-1] Connecting Biology to Real Life in a College Non-majors Course (*A0194*)

Pradeep M. Dass
Center for Science Teaching and Learning, Northern Arizona University, USA

ABSTRACT Elementary teacher education candidates and students from other non-science major disciplines typically take 6 – 8 credit hours of science courses (often involving only one lab science course) as part of their liberal arts education requirements in college in the USA. Yet, the immense and increasing influence of science and technology on our lives in the 21st century demands a strong understanding of the basic principles of science and an ability to make informed, intelligent decisions and choices based on that understanding both at personal and societal levels. Since the minimal 6 – 8 credit hours worth of education in the sciences is far too little in preparing college students to effectively deal with and function in a science and technology laden society, it is critical that these science education courses not be merely a simplified version of the courses designed for those who will be majoring in that discipline. Rather, they should be designed in such a way that while students learn the fundamental concepts and principles of that discipline, they understand them in the context of some real life situations, questions, concerns, issues, and problems. They should also offer opportunities for students to learn to apply these concepts and principles to address real life situations, issues, concerns and problems. In other words, the collective learning experiences in these courses should have real life relevance and impact for students in order for our future societies to have a respectable level of "scientific literacy". With this intention in mind, a non-majors introductory college biology course was redesigned to provide explicit connection between biology and real life. The course was designed around the following three Essential Questions (EQs): 1. Why do we look (appear) the way we do? This question was addressed through a unit on genetics, including molecular genetics (structure of DNA, transcription, translation, mutations) and genetic technology (DNA Fingerprinting, GMO, etc.). 2. Who is around us and how are we connected? This question was addressed through a unit on ecology and environment including ecosystems, community and population studies, and human impact on environment. 3. How did it all come about? This question was addressed through a unit on biological evolution including a historical background, Darwin's work, mechanisms leading to the emergence of new species, and evolution of biological diversity. In order to assess student understanding of the real life relevance of what they learned in each unit, they were asked to respond to the following question in the form of a short essay administered as a pre- and post-test. What is the usefulness/relevance of biology to me? The pre- and post-essays were scored and analyzed for references to real life situations to determine the impact of the course design including specific course assignments on students ability to make connections between the disciplinary content addressed in the course and real life situations, issues, etc. The goal was to enable students to take what they were learning in the course and apply it to better understand and address, where possible, the events and situations they were encountering in real life. The change from pre- to post- essays was scored according to the following scheme. 0 = Either no change in ideas Or no mention of specific topics/examples 1 = Mentions at least one topic; no or vague examples 2 = Mentions two topics with clear examples 3 = Mentions all topics but either all examples are not clear or all topics are not discussed equally well 4 = Mentions all three topics with clear examples and equally strong discussion of each topic The proposed presentation will provide details of the course design, assignments students were given, methodology by which their pre- and post-essays were analyzed, and results of the impact the course had on students, particularly in the context of certain specific assignments that were designed to enhance student ability to connect course content to real life.

[27O4L-2] Learning-progression-based Teacher Professional Development: A Quasi-experiment Study in High School Physics (*A0257*)

Yu-Xuan Xiang* and Yu-Ying Guo+

Department of Physics, Beijing Normal University, China Mainland

ABSTRACT As one of the core research paradigm, learning progression has received great attention from science educators around the world (NRC, 2007; Alonzo & Gotwals, 2012). Previous research spent most of their efforts on developing a learning progression framework through cross-age assessment, but recently scholars called for more studies on application of learning progression in the classroom instruction (e.g. Duschl, Maeng, Sezen, 2011; Lehrer & Schauble, 2015; Duncan & Gotwals, 2015). As a response to their calls, this paper presents our means toward this kind of application through learning-progression-based teacher professional development. The whole research, which is taken in the key middle school in Beijing, followed a quasi-experiment design: Teachers in experimental group received teacher professional development lessons while the teacher in contrast group didn't. The content in teacher professional development lessons included the idea of learning progression, learning-progression-based instructional design model, specific learning progression framework related to the unit, etc (Yao, Guo, Neumann, 2016). After the unit-teaching which contains four lessons (45 min for one), a mixed method was used to reveal the effects of the professional development: We conducted video analysis to observe teachers' behavior (Fischer, Labudde, Neumann, Viiri, 2014), and carried on pre/post assessment to measure students' performance (a Rasch analysis was used to link and compare students performance before and after instruction). The sample is consist of 37 students in experiment group and 41 students in contrast group. The results showed that: (1) After the instruction, students in all groups improved significantly on the understanding of disciplinary knowledge ($p < 0.05$). (2) The instructional behavior of teachers in experimental group exhibited a different pattern comparing to instructional behavior of teachers in control group. (3) While there was no significant difference between contrast group and experimental group before instruction, students' disciplinary capacity of physics improved significantly in the experimental groups, but not in the control groups. (4) Teachers' self-reflection suggested a shift of identity from the dominator of the class to the guider of learning. This study ended with a discussion on that the "progression" is not only of the students, but also of the teachers.

[27O4L-3] Investigate the Influences of Teachers' Teaching Beliefs in their Instructional Strategies (*A0505*)

Ying Kuan[1]*+, Ya-Hui Hsieh[2+], Jyh-Chong Liang[1], and Chin-Chung Tsai[1]

1. Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology and 2. Center for Teaching and Learning Development, National Kaohsiung University of Applied Sciences, Taiwan

ABSTRACT The ability of instructional design is essential for preschool teachers. This study investigated how different teaching beliefs of the in-service preschool teachers may influence their instructional strategies. Data were first collected from forty-seven scientific lesson plans of in-service preschool teachers in Taiwan. Quantitative survey and content analysis were adopted in the study. Then, ten in-service preschool teachers were divided into the constructive group (more sophisticated teaching belief) and nine in the traditional group (naive teaching belief), by the scores of teaching belief questionnaire. The teaching belief questionnaire consists of eight items examining teachers' internal thinking possessed during the teaching process in regards to their belief about knowledge. The results showed that there was no apparent difference in clear teaching concept between the constructive and traditional groups and both groups emphasized on constructing context in the warm-up part of the lesson plan. However, teachers in constructive group have more clear orientation toward teaching concept and various teaching strategies, such as discussion, playing games, practice, observation, explanation etc. in the activities part of their lesson plans. Moreover, the strategy of field-trip only used in the constructive group.

Oral 5 (28th, 09:00-11:00)

<5A> Learners (Teaching/Learning)

Chairs: Derek Cheung (The Chinese University of Hong Kong), Sung-won Kim (Ewha Womans University)

[28O5A-1] The Effect of Messages Interference on Students' Creativity for Bags Design (*A0089*)

Jian-Hong Ye[1]*+, Jon-Chao Hong[1], Jing-Yun Fan[2], and Hung-Shun Huang[1]

1. Department of Industrial Education, National Taiwan Normal University and 2. Department of Fashion Design, Tainan University of Technology, Taiwan

ABSTRACT This study investigates the effect of messages inference on students' creativity for bags design, which studies whether students decrease creativity for bag design because of messages inference through experimental situations and investigates the effect of situations and domain expertise on creativity. "Domain Expertise Test" and "The Scale of Creative Performance on Experiments" compiled by the researcher and "Creativity Thinking Test" are utilized in this study. The objectives of this study are students studying in the second grade of Department of Fashion Design in one University of Science and Technology in Taiwan and purposively sampling is adopted in this study, which uses blind assignment to divide the sample class into the control group with messages inference and the experimental group without messages inference and carries out testing the creativity for bags design. The control group can see the experimental content that the members in the same group fill in. However, the experimental group cannot see the experimental content. According to the result, three experts on bags design evaluate the creativity grades of creative performance on experiments. This study takes the results of creativity test on bags design, creativity thinking test and domain expertise to carry on Independent- Sample T test, Correlation through IBM SPSS 22.0 and adopts Partial Least Square to carry on Path Analysis. The study found the following outcomes. First, the students in the experimental group showed better performance on the creative experiments than the students in the control group. The result showed significant differences and proved that absorbing too much information could affect the

performance on creativity. Next, the students with higher score on creativity thinking test have higher score on testing creativity for bags design. Last, students with higher score on domain expertise have lower score on creativity performance of bags design. Finally, this study proposed relative advices according to the findings.

[28O5A-2] Analysis of Elementary School Students' Understanding of Light by Conceptual Metaphor Theory (*A0547*)

Jinkyu Jung*[1], Ji-Ae Lee[2], and Youngmin Kim[+1]
1. Pusan National University, and 2. University of Ulsan, Korea

ABSTRACT Students often have a difficulty to construct abstract and unfamiliar scientific concept. It is easier to learn the familiar and the concrete as what they can see, hear, feel and touch. According to the theory of conceptual metaphor, human use their interaction in their surrounding world to make a structure of their intuitions of subjective and abstract domains (Lakoff, 1993; Lakoff & Johnson, 1980, 1999). Especially, the human conceptual system contains more than hundreds of primary metaphor related to their sensorimotor experiences with subjective experiences and judgment. Primary metaphor allows people to apply image schema from sensorimotor experiences to the abstract and the unfamiliar in other domains. Examples of image schema include the container schema, in which we conceptualize an inside, an outside and a separating boundary and the source-path-goal schema, through which we conceptualize an object moving along a path, from a source to a goal. In science education research, various researchers have tried to apply conceptual metaphor theory to analysis of student's learning process. Many researchers who focus on development of learners' conceptual understanding of energy have emphasized the advantages of using a substance metaphor for energy (Amin, 2009; Brewe, 2011; Dreyfus et al., 2014; Lancor, 2014). The purpose of this study was to analyze of elementary school students' understanding in their writings of light concept with conceptual metaphor theory. 6th grade elementary students (n=53) asked to write their experience about light. In students' writings about light related to their daily life, we categorized them as three dimensions as existence of light, what light do, and where light is. In 'existence of light' dimension, there were three types of students' perception interacted their experience in daily life which were light as substance in space, visual effect of light, and sources of light. In 'what light do' dimension, there were three types which were light as entity, sensitivity about light, and existence and function of light source. In 'where light is' dimension, there were perception of light as free entity in space, focus on surface of light source. Through the dimensions in students' writings, we found image schema in students' metaphor of light. The image schema of light analyzed in this study were polarity schema, space schema, process schema, container schema, force or causation schema, unity or multiplicity schema, identity schema, existence schema. Students expressed their thoughts about light in metaphorical expression, using several image schemas. Analyzing students' metaphors of light, we found the structure of early stage to develop students' light concept.

[28O5A-3] The Development of Project Based Learning Unit of Solution Process for Grade 11 Students (*A0303*)

Patiwat Sritipsak* and Pattamaporn Pimthong[+]
Department of Science Education, Kasetsart University, Thailand

ABSTRACT The purpose of this action research was to promote grade 11 students' understanding of solution process. The participants were twelve Grade 11 (16-17 year old) students. An instructional unit based on the project based learning was developed and implemented. There were five lesson plans (10 hours) with activities prepared for the students to clarify their problems and plan their projects, search for data, create and present their projects. The data were collected by classroom observations, students' artifacts, students' interviews, students' reflective journals and teachers' logs. The results showed the way to enhance students' scientific conceptions namely, teacher should encourage the students to follow the step of planning, searching for data, creating and presenting their projects. The teacher should be a facilitator who uses driving questions to enhance students' planning and creating their projects. Moreover, the teacher should encourage students to take their authority in their projects. Finally, teacher's feedbacks were important in order to encourage students' creativity and revising their plan. The results also showed the difficulties for implementing project based learning in normal Thai classroom because the lecture based instruction is rooted in science classroom culture, the Entrance examination system which emphasise only on content knowledge and most students were unfamiliar with work collaboratively with others.

[28O5A-4] How Accurately Can Individual Interest in Science, Situational Interest, and Science Self-concept Predict Individual Interest in School Science for Secondary School Students? (*A0167*)

Derek Cheung
The Chinese University of Hong Kong, Hong Kong

ABSTRACT Student interest is an important variable in science education. Individual interest in school science can be defined as a relatively stable and enduring preference toward learning science in school for intrinsic and/or instrumental reasons. To date, few empirical studies have investigated the relative importance of key predictors of students' individual interest in school science. In the present study, questionnaire items were constructed to measure three predictors: individual interest in science, situational interest in science lessons, and science self-concept. Data were collected from 591 junior secondary school students in Hong Kong. A multiple regression analysis revealed that the linear combination of the three predictors was significantly related to individual interest in school science, $F(3, 587) = 740.894$, $p < .001$. The sample multiple correlation coefficient was .889 and R square was .791, indicating that 79.1% of the variance of students' individual interest in school science in the sample can be accounted for by the linear combination of the three predictors. The most powerful predictor of students' individual interest in school science was their science self-concept (beta = .459), followed by situational interest in science lessons (beta = .264). The implications of these findings for science teaching and learning in secondary school are discussed.

[28O5A-5] The Influence of Affective Domain in the Physics Problem Solving Process (*A0523*)

Sungeun Lee[1]* and Sung-Won Kim[2+]

1. Ewha Womans University and Sungkeunkwan University, and 2. Ewha Womans University, Korea

ABSTRACT The purpose of this research is to explore the influence of affective domain in the performance of student's physics problem solving activities. This research focuses on students who show low performance in physics problem solving with the poor knowledge of problem solving strategy, in the process of problem solving. When students solve the problems, they often experience feelings which cause tension in their search for a strategy to find solutions. This may result in interest or, on the contrary, in a blockage due to the weight of negative emotions triggering anxiety and or abandonment (Caballero et al., 2011). It is now well-recognized that positive affect leads to greater cognitive flexibility and facilitate creative problem solving across a broad range of settings (e.g., Aspinwall & Taylor, 1997). So, the affective domain influence on physics problem solving should be studied. Most of high school Korean students have a belief that learning physics is difficult. Moreover, some students tend to reject physics study. The reason could be earlier fails in physics class or successive fails in math class because the math skills, analyzing graphs and equations, are frequently used in physics problem solving. The fails in physics problem solving can induce students to experience emotional negative affect, such as frustration and sadness. To accomplish this research, a survey was conducted with 5 second-grade male students of an autonomous private high school, Seoul city, about a week later midterm exam of the first semester, 2016. All of them have the plan to study science at university. According to the study of Ferreira & Custódio (2013), two activities were given to the students. In the first activity, the students completed a written test in a laboratory between classes. The test lasted on 30 minutes. The three physics withdrawal-type problems of the lesson "Force and Motion" were given to students. In the test, students were asked to put emotion-symbol stickers on the prepared answer sheet to express their emotions and feelings characterized as the type and intensity occurred in each step of the problem solving. We requested students to comment about what they felt and thought, with their own words. The emotion-symbol stickers were adapted from ones in Ferreira (2012). They are consist of emotions and their derivations defined and conceptualized in studies on human emotions (Izard, 1977). In the categories of the emotions, there is "unchanged" or "normal" as an emotional situation in which students do not observe or feel any emotional reaction. The first problem is analyzing a velocity-time graph of an object that moves along a straight line to calculate the average acceleration and the distance of the object. The difficulty level of it is relatively low. The second problem is analyzing a momentum-time graph of a system which is composed of two objects and using Newton's second law to calculate the force and the acceleration of the objects. The difficulty level of it is relatively high. The third problem is an essay-type and multiple-choice problem about "Einstein's Special Relativity". The level of difficulty is a little high. With the 3rd problem, we could check the degree of students' understanding of "Einstein's Special Relativity" and the ability to describe their thought in written words. After every each problem solving activity, a correct-response feedback (Shute, 2008) was given to students immediately. In the second activity, the students were asked to express the change of their influences on an instrument called emotional graph adapted from Gómez-Chacón (2003). When the students got a correct-response feedback after the first problem solving activity, the emotion-stickers were changed from "normal/no change" to positive ones which expressed "Happiness", "Satisfaction" in most case. The students more frequently expressed negative influences, "Frustration", "Sadness", "Anxiety", "Annoyance" during the second problem solving activity. The student who got the highest grade in the midterm exam strongly expressed "embarrassment" after the incorrect- response feedback. Almost of the students expressed "Interest", "Happiness" and "Joy" in the third problem solving. The third problem was a question of the concept of "Einstein's special relativity". The positive influences and the preference of the third problem might result from the teacher's perspective and teaching method in physics class which focused on understanding physics concepts and principles. When the student wrote their answers on the answer-sheets, the negative influence was increased. This may be because of that the students could not know if their answers were right or not, especially for the students with low knowledge for the problem solving strategy. But the negative influence decreased after they got the correct-response feedback. In some cases, the negative emotion for the fail in the previous problem solving did not so much influence at the moment when they started the next problem solving. We expect that the correct-response feedback can influence on the affections of students who show low performance in physics problem solving. The hypothesis of this research is that the impact of feedbacks on students' affective state and the experience of problem solving accompanied positive emotion would improve students' problem solving ability. Vygotsky (1987) observed that the study of psychology had been damaged by the separation of the intellectual from the motivational and emotional (or affective) aspects of thinking. Crafting and delivering formative feedback may help bridge these aspects of thinking and enhance learning. This seems to be supported by a growing number of researchers (e.g., Goleman, 1995) who have argued that emotional upsets can interfere with mental activities (e.g., anxious, angry, or depressed students do not learn) (Shute, 2008). Thus our future research is to investigate systematically the relationship(s) between affective components in feedback and the performance of physics problem solving to enhance students' problem solving ability in physics.

<5B> Teacher Education (Teaching/Learning)

Chair: Hui-Ju Huang (California State University, Sacramento), Romklao Artdej (Khon Kaen University)

[28O5B-1] Physics Teachers' Perceptions of Professional Development Program about Use of Animations and Simulations in Teaching (*A0074*)

Mehmet Fatih Tasar*+, Duygu Yilmaz, Merve Lutfiye Senturk, Jale Ercan Dursun, and Meltem Irmak

Gazi University, Turkey

ABSTRACT Teachers' effective use of Information and Communication Technologies (ICT) is an important concern

for educators (Chai, Koh, Tsai, 2013). In-service professional development (PD) programs play a crucial role in introducing teachers how technology, pedagogy, and content can be integrated (Guzey & Roehring, 2009; Lawless & Pallegrino, 2007). Haslam (2010) suggested examining participants' views about PDs may be an important indicator of whether and how they are likely to apply new knowledge and skills in their teaching practice. Therefore, main goal of this research was examining two physics teachers' perceptions of a PD program which focused on using animations and simulations (AS) in physics teaching. Thus, the research question of this study was: What were the two physics teachers' perceptions of the PD program which focused on using AS in physics teaching? This study employed a case study design. It was conducted after the 'Physics teaching with AS' PD program organized by the research team. The main focus of the 5 day PD was introducing how AS can be used in physics instruction effectively. We interviewed two volunteer female teachers (nicknamed Halime and Zeynep) about their views for the PD program. The interview questions focused on categories of Haslam's (2010) guide which are: 1. Understanding the purpose 2. Ratings of the usefulness of key components. 3. Perceptions of the extent to which the PD met participants' needs 4. Ratings of the alignment of the content of the PD with improvement priorities 5. Perceptions of support and encouragement to participate in the PD 6. Perceptions of support and encouragement to apply new knowledge and skills 7. Ratings of the likelihood of applying new knowledge and skills in the classroom 8. Overall ratings of the usefulness of the PD compared with others In sum the results are as follows: Before coming to the PD the participants did not have a clear idea about the purpose of the PD. But they quickly understood that preparing animations and simulations requires some expert skills and knowledge that they cannot accomplish by themselves as a teacher. Zeynep found the PD very useful in terms of understanding AS and other instructional technologies to be used in her classroom so that her needs were met in the program. However, Halime stated that it was not easy for her to retain all she learned during the PD. Although teachers were assigned to the PD by their institutions, they thought that the activities conducted in the PD arouse their motivation and encouraged them to participate. Teachers stated that they either become more aware of the importance of integration of instructional technologies and especially AS or active involvement of students in technology integration process. They were also content that the PD gave them some practical knowledge that they can immediately use. In conclusion, teaching needed knowledge and skills, indicating purpose of the PD clearly and ensuring active participation of teachers should be taken into account in further PD programs. Implications for future PD initiatives in this field will be provided. [Draft]

[28O5B-2] Envision Science Standards for STEM Excellence (*A0214*)

Hui-Ju Huang
California State University Sacramento, USA

ABSTRACT [Problem Statement] Ambitious efforts are taking place to implement a new vision for science education in the United States in Next Generation Science Standards (NGSS). The NGSS explicitly calls for a multidimensional approach to teaching science. How motivated and prepared are pre-service and in-service teachers to use new standards? [Purpose] The current study aims to examine and explore teachers' perceptions on new standards by gathering evidence through empirical research approach. Understanding teachers' perceptions is essential for teacher educators to develop a support system that will help teachers work effectively in achieving the goals of NGSS and broader science education reform. [Methods] The data collection of the study included: (a) 20 classroom teacher interviews and teachers are from elementary and secondary schools of three school districts in California state, U.S.A. The interview topics included lesson planning expectations, current instructional approaches, teachers' perceptions of NGSS, (b) 35 pre-service teachers' lesson plans and reflections of using NGSS and pre-service teachers are from a teaching credential programs in California state, U.S.A. The analysis focus on establishing topical categories that emerged from interview responses and writings. The recurring regularities in the data are identified and grouped into general characterizations. The verbatim statements are used to support these generalizations. Categories are compared across individuals and continuously refined to identify and capture emergent patterns within and across individuals. [Findings] The results show that the classroom teachers shared a belief in the value of multidimensional and integrated approach to teaching science. They acknowledge that the new standards make connection to the common core standards. They expressed a desire to learn more about the new standards and anxious to see the bridge between current and future practices. The biggest challenge is the effective integration of all three dimensions in the classroom. They are also concerned about the lack of resources for engineer practice. The pre-service teachers have been working on inquiry-based instructions in the teacher preparation program. The focus on inquiry remains strong in the era of NGSS. They feel excited that students will be able to use both conceptual and procedural understanding and apply knowledge in context. They appreciated that the disciplinary core ideas provide familiar and safe ground because they include the ideas of traditional content teachers have prioritized in the past. They acknowledge that they need different ways of thinking, lesson planning, and instruction to meet the challenges of implementing new standards. They are concerned about the pressures of standardized assessments and the finical support of developing quality instructional materials. [Conclusions/Implications] The theme of EASE conference calls for international collaboration, I will be honored to present and share my study with colleagues in the region. Common practice for many science teachers in U.S. has been to emphasize content knowledge first, application next, and connections between and across disciplines last. Effective implementation of NGSS demands a fundamental shift in this practice and such a large change won't happen instantaneously. We're pioneers on this new frontier, I look forward to the discussions and suggestions from conference participants.

[28O5B-3] Thai In-service Teachers' Competence in Designing Science Learning Activities to Promote Science Process Skills for Primary School Students (*A0322*)

Chaninan Pruekpramool
Srinakharinwirot University, Thailand

ABSTRACT In Thailand, the professional development of teachers has been set as a priority task of education policy. In terms of raising the professional standards, we have continuously been supporting and providing training programs to both pre-service and in-service teachers in all subjects. Regarding the process of professional development on teaching and learning science, science process skills are certainly important for all levels of students. Emphasizing on science process skills, a three-day workshop was provided for 80 Thai in-service teachers in Sa Kaeo province located in the eastern part of Thailand. These teachers had consistently taught in science subjects in primary school level, although, some of them did not earn the degree in the science area. The most important purpose of the workshop was to help them to be able to design their own science learning activities in order to promote science process skills for students. During the workshop, 30 science learning activities for grade 3 to 6 students were created by 15 groups of teachers. The activities were categorized into 4 main concepts of science which were Physics (7 activities), Chemistry (9 activities), Biology (11 activities), and Earth science (3 activities). Teachers' competence in designing science learning activities was assessed from their presentations and works. Considering the activities, we found that most activities were explicitly designed to promote more than two science process skills. In addition, the five science process skills that teachers commonly used to design the activities were observing, classifying, experimenting, inferring, and interpreting data and making conclusions, respectively. On the contrary, defining variables operationally and using space-time relationships were the least frequently used to design the activities. Moreover, there were some misconceptions in science concepts and some imprecise parts about how to promote each science process skill in the activities that required clarification.

[28O5B-4] A Case Study of Improving Science Lesson Study Activity in a Pre-service Teacher Training Course (*A0323*)

Hayashi Nakayama* and Tomokazu Yamamoto
University of Miyazaki and Hyogo University of Teacher Education, Japan

ABSTRACT In the previous study on pre-service teacher training, we found that repeated trial lesson study and immediate web-based assessment* could make students focus more on "conceptual change," develop metacognitive views of science education, and become more aware of scientific enquiry and the link between scientific knowledge and everyday events. In our action research on pre-service primary school teacher training for science education, we set annual objectives and assessed them by change in student response to the web-based questionnaire. Almost the entire plan had been implemented, but which factors affected students' views of science lessons was unclear. However, we are aware that repeated questionnaire items in web-based trial science lesson assessment might have made students change their minds. Therefore, we decided to focus on effectiveness of repeated trial science lesson assessment by students. The research question was "which design principles are effective in improving students' views of science lessons?" We determined design principles as follows: (1) Students gain important viewpoints for observing science lessons by sharing the points of assessment of the lessons. (2) Students confirm the points for comprehending science lessons by assessing the lessons repeatedly. Accordingly, we established 14 items, like those given below, for web-based assessment. The students responded to these immediately after every trial science lesson: -The teacher's questions on the events or phenomena were good. -The "problem" for students to challenge was good. -Context in the lesson was set effectively. -The conclusion corresponded to the problem. -The verbal communication activity applying acquired knowledge was fruitful. and -Conceptual change occurred through the lesson. A series of five trial "primary school science" lessons (1. Weight and volume of things, 2. Nature of bubbles in boiling water, 3. Weight of salt dissolved in water, 4. Gas before and after burning, 5. Why the moon waxes and wanes) were planned. A group of students acted as "primary school teachers" and others acted as school children. The "teachers" made a teaching plan, prepared observation or experiment activities for the "children," and conducted a 45 minute trial science lesson. Immediately after the trial lesson, both "teachers" and "children" assessed it through the web-system using mobile phones or PCs. We assessed the effect of a series of our lessons through 20 pre and post questionnaire items. Positive answer frequency increased in almost all items. The positive responses increased significantly in the following two items: (12) in a science lesson, a child explains his/her idea to children with a different idea, (19) a context set in a science lesson. The former item is about the importance of argumentation, and the latter is about the importance of context in a science lesson. Japanese students are not yet familiar with these viewpoints. We think that trial science lesson items were effective in making students share important points; therefore, we consider our design principles effective. However, students' conviction in these points is not as strong. Consequently, we should try to create effective designs for pre-service teacher training classes. (*We used the Real-time Evaluation Assistance System (REAS), a Web-based system provided by the Center of ICT and Distance Education, The Open University of Japan, Chiba.) [This work was supported by JSPS KAKENHI Grant Number 24300271 and 16H03063.]

[28O5B-5] Case Studies Involving Pre-service Chemistry Teachers: Training in Pedagogical Design of Model-based Instruction (*A0347*)

Romklao Artdej
Science Education, Faculty of Education, Khon Kaen University, Thailand

ABSTRACT The purpose of this study was to investigate pre-service chemistry teachers' pedagogy design capacity of model-based instruction. Four pre-service chemistry teachers who studied in the science education program were selected as case studies. Lesson plans and reflection assignments were gathered individually to assess how they modified their lesson plans after getting feedback from students. The types of modifications in their lesson plans that were used in data analysis included insertions, deletions, substitutions, duplications, inversions,

relocations, and rewriting. The number of modified lesson plans depended on how each case study was able to design learning activities to be consistent with the ideas of model-based instruction. These lesson plans were completely revised as suggested by the researcher before implementation in the classroom. Such feedbacks acted as a scaffold for helping the pre-service teachers to comprehend the design of lessons to enhance the modeling process. Written reflection assignments were also used to support findings from lesson plans. The findings revealed that the type of modification found in lesson plans from four case studies was different. Importantly, the frequency of modifications was relevant to the personal beliefs and subject matter knowledge of the pre-service teachers. This research yields valuable information for teacher preparation prior to the pre-service teachers going out on teaching practice.

[28O5B-6] Assessment Analysis of Mock Science Lessons of Student Teachers (*A0452*)

Hironori Sasaki
Chugokugakuen University, Japan

ABSTRACT In 2009, the Central Council of Education in the Ministry of Education in Japan released "Future teacher training and the license system as they ought to be". The establishment of "on going learning professional teacher" model was required in Japan. The faculty student teacher training course, which the author of this article belongs to, was looking for a model of "a teacher as a professional". After discussion among faculty staff members, a "reflective practitioner" model was introduced in 2014. Consequently, the faculty staff members developed a student teacher training program which consisted of 15 lessons for 3rd and 4th grade student teachers. The goal of the teaching program was to improve the practical instrumental competence of teachers through reflection. The training program was modified and the mock lessons were introduced to the lesson in 2015. The author was in charge of mock science lessons. The assessment was important to reflect their practice. Therefore the objective of this study was to clarify how student teachers reflected their mock lessons. In the lessons, 29 student teachers were divided into 6 groups. They discussed about lesson plan and prepared teaching materials for the mock lesson. Three kinds of assessment were introduced. The student teachers rated their own competency before and after the mock lesson (self-assessment of competency), the student teachers who taught in the mock lesson rated their own teaching (self-assessment of lesson), and other student teachers who observed the lesson rated the mock lesson (peer-assessment). Questionnaires, which consisted of 45 questions, were used for the assessment. As a result of analyzing three kinds of assessment, some consequences were clarified. One of them was as follows. In the self-assessment of competency, there were significant differences (5%) between before and after the mock lesson as for the competency of making teaching plan appropriately and writing on the blackboard effectively. Some other consequences were also clarified from self-assessment and peer-assessment. As a conclusion, several suggestions to improve their practice were given based on those consequences.

<5C> Learners (Curriculum/Assessment/Policy)

Chairs: Jian Wang (Beijing Normal University), Tsung-Hui Cheng (National Dong Hwa University)

[28O5C-1] Exploring the Changes of Students' Cognitive Structure Based on HPS Teaching Strategy Measured through Word Association Tests (*A0177*)

Qing Zhou*, Li Zhou, Hui Gao, YaFei Zhou, and JunChao Wei
Shaanxi Normal University, China Mainland

ABSTRACT The purpose of this study is primarily to demonstrate the HPS-based teaching strategy can facilitate the students' understanding of chemical concepts through exploring their cognitive structure with the method of word association tests. Periodic Table was chosen as the topic which plays a significant role in both understanding of the chemical elements and demonstrating the history and philosophy of science. The subjects of this study were grade 1 students (15-16 years old) come from class 3 (the experimental group) and class 4 (the control group) at Dong Yuan Road Senior High School in Xi'an in China. The students of experimental group experienced the instruction of Periodic Table with the context of HPS, while the students in control group were taught as the traditional method without emphasis on the history and philosophy of science in the classroom. The results showed that the richness and links between stimulus and response words of the post-instruction of experimental group is better than that in control group, although the cognitive structure before instruction of the control group is more informative than that of experimental group. The findings indicate that the HPS-based teaching strategy is better than the traditional method. [Draft]

[28O5C-2] Formative Assessment in High School Physics (*A0126*)

Syoji Zeze
Yokote Seiryo Gakuin High School, Japan

ABSTRACT Active learning has drawn much attention from Japanese teachers since it has been featured in the national reform plan for middle education. On the other hand, the strategy of formative assessment, which has proved to be effective to improve student's engagement in active learning, is not yet popular among teacher's community. In particular, only few reports have been available for practices in science classes [1, 2] . We present a formative assessment strategy focused on problem solving in high school physics courses. Our strategy is based on the well-known ARG statement that identifies assessment for learning as a process of seeking "where we are, where we need to go and how to get there". Former part of the presentation is a report on various assessment practices including four criteria rubric for problem solving competencies, assessment of the homework-test cycle inspired by ``Akita method" and the MPEX [3] result. Outcomes are improvement of test score and almost perfect submission rates of the homeworks. In latter half of the presentation, we try to explain the effectiveness of formative assessment by employing an analogy with the process of scientific research. Formative assessment is understood to be collaboration on learning science in a classroom. Based on this understanding, we also present an "exploration" model for learning which nicely explains an importance of formative assessment. In this model,

process of learning is identified with finding invisible "path" a student explores. Evidences from the practices indicate that most students feel it difficult to find a suitable way to reach the goal even though they are good at identifying their start and goal.

[28O5C-3] Exploration of Secondary School Students' Understanding about Crosscutting Concept (*A0455*)

Yunhee Choi* and Sung-Youn Choi+

Soongmoon Middle School and Dongguk University, Korea

ABSTRACT The purpose of this study is to explore secondary school students' understanding about crosscutting concept in "Cause and Effects" and "Energy and Matter". Crosscutting concept is a way of linking the efferent domains of science to provide students with connections and intellectual tools that are related across the differing areas of disciplinary content and to enrich their application of practices and their ideas of science. We focused on "Cause and Effects" and "Energy and Matter" as crosscutting concepts and modeling skills as a scientific practice. Based on the Construct-Centered Design process, we developed a set of "Cause and Effects" items to assessment student's explanation and modeling skills starting from their own ideas and compare to scientific theories that explain causal mechanisms in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. We also developed a set of "Energy and Matter" items about examining systems in the water cycling through Earth's systems driven by energy from the sun and the force of gravity. Total two hundred fifty middle school students and one hundred high school students participated in a test and fifteen students had a following interview. The results indicated that most of students had scientific identification of water molecules in its different states, while they had difficulty with the cause of phase changes and the relationship between energy and molecular status. The results also showed secondary school students had difficulty when asked to apply their own model to scientific phenomenon such as water cycling or phase change. From the results, we provided key factors of crosscutting concepts and teaching strategies in "Cause and Effects" and "Energy and Matter." [Draft]

[28O5C-4] Assessment of Grades 7-12 School Students' Scientific Reasoning Ability (*A0558*)

Cong Wang* and Jian Wang

Beijing Normal University, China Mainland

ABSTRACT Science Education Standards worldwide put much more emphasize on scientific inquiry, of which scientific reasoning is the key component. Is there any pattern about student's scientific reasoning ability? Do different types of reasoning abilities develop harmoniously? This study addresses these questions. We developed an instrument to assess middle school students' scientific reasoning ability. Totally 2205 students from 23 middle schools in Beijing were involved in this study. Data was analyzed with One-way ANOVA, linear regression model and Logistic regression and Rasch model. The student reliability and item reliability of the instrument are 0.79 and 1.00, which shows the instrument can assess student's scientific reasoning ability. The results indicate that: (1) Student's general scientific reasoning ability develops ascendingly with their grade going higher from 7 to 12. (2) Different types of reasoning ability develops unevenly. Students perform the best with simple inductive reasoning items. And their performance on the other four reason abilities goes down in the order of control variable reasoning, causal reasoning, hypothetical deductive reasoning, and proportional reasoning. (3) Regarding the two types of reasoning task, analytic and designing task, students perform better with the former than the latter. Based on the above findings, this study suggests science teachers should provide students opportunities and appropriate tasks to use different types of reasoning ability to solve problems.

[28O5C-5] Seventh Grade Students' Mental Models of Blood Circulation During Exercise (*A0602*)

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Department of Curriculum Design and Human Potentials Development, National Dong Hwa University, Taiwan

ABSTRACT Recently the Next Generation Science Standards (NGSS), promotes three distinct and equally important dimensions (Crosscutting Concepts; Science and Engineering Practices; Disciplinary Core Ideas) to learning science from students' diary life, which makes the high expectations for what students should know and be able to do（NRC, 2013）. Dodds, Griffin and Placek (2001) pointed out students will learn several science concepts during playing balls and running in the Physical Education classes. While learning new things, learners' prior knowledge plays an important role in the learning process. Researchers have verified the role of learners' prior knowledge. According to Vosniadou's Framework Theory, students generate mental models from their knowledge base, during their learning processes. However, little did us understanding of how students' mental models on blood circulation are generated when they are running in Physical Education classes. Therefore, the purpose of this study was to explore seventh grade students' metal model on blood circulation during exercise, based on the Vosniadou's Framework Theory. This study conducted the research using qualitative approach. We designed several situation questions to probe students' mental models during exercise. All participants were 31 seventh grade students. Data were collected using the semi-structured interviews by using scenarios and open-ended questions. The findings showed an initial mental model and three synthetic mental models. Those mental models presented students' knowledge of blood circulation after they are running. Through the enrichment stage, students' gradual growth presented in the different mental models. Students' experience of real world effects theirs explanations, and physical education included science concepts as a domain-specific knowledge. Future research could explore the mental model by developing curricula and teaching methods approaches to promote students' concept of change.

<5D> Curriculum/Teaching Materials (Integrated (SSI, EE, ESD))

Chairs: Yanlan Wan (Shandong Normal University), Verena Pietzner (Oldenburg University)

[28O5D-1] Chemistry of Fungi in Chemistry Classes of Lower and Upper Secondary Level (*A0065*)

Farina Bunjes[1], Martin Rühl[2], Peter Feischmann[1], Holger Zorn[2], and Verena Pietzner[1*+]

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ABSTRACT Chemistry offers many options for innovative, multidisciplinary teaching. To foster multidisciplinary learning in chemistry classes, the topic of Food Chemistry and in particular the Chemistry of fungi meets the criteria set out in an outstanding way. Fungi provide with their variety of different ingredients several starting points for multidisciplinary, application-oriented and at the same time demanding lessons. As part of the work presented here, we worked with cultivated button mushrooms (Agaricus bisporus) and oyster mushrooms (Pleurotus ostreatus) to develop concepts for the integration of fungi in chemistry teaching on both secondary levels. Overall, the inclusion of mushrooms in teaching chemistry offers many opportunities to deepen knowledge of chemistry and networking. Firstly, the students can apply detection reactions they already know for the analysis of mushrooms ingredients. Secondly, the area of enzymology can be treated to achieve an integration of life orientation in the classroom. Both topics are part of the German Chemistry Curriculum. For the experiments are new to the German curriculum, classroom related evaluation criteria are currently developed by our group. In lower secondary level, major components (like carbohydrates, fats, proteins) and selected minor components (vitamins, minerals) can be detected using common detection reactions. Moreover, in upper secondary education, the enzyme classes of laccases and cellulases are explored by student experiments in chemistry classes (reaction rates of DMP and ABTS with laccases, detection of glucose with cellulases) and their industrial uses can be discussed. Laccases are used e.g. in wine cork stopper treatment to reduce the cork taint, and cellulases are used in the textile industry to provide a washed denim look of jeans. The presentation will introduce into the chemistry of fungi as well as selected experiments.

[28O5D-2] STSE Education in Three Science Textbooks of Junior High School (*A0603*)

Chengcheng Bao*, Bing Lv, and Xiao Huang[+]

College of Teacher Education, Zhejiang Normal University, China Mainland

ABSTRACT Science, Technology, Society and Environment education is the focus of international research and education reform. As one of key objectivity of science, STSE is stressed in both the science curriculum standard and science textbooks. What aspects of STSE are presented in three sets of science textbooks will affect STSE teaching, therefore, our study focus on the comparison of STSE in science textbooks of United States, Taiwan and the mainland. Science Explorer is one popular science textbook for Junior school students of America, Science and Technology is one version of science textbook for junior school students of Taiwan and the Science published by Zhejiang publishing house is most popular science textbook for junior school students of mainland. Taking these three science textbooks as research objects, six dimensions contains “impact of science on technology”, “technology on science”, “science and technology impact on the social environment”, “influence of social environment on science and technology”, “social impact the environment”, “Environment impact on the community”, are chosen and designed to compare and analyze the STSE content in qualitative and quantitative ways. the quantitative analysis is given according to the units include the description of the dimensions of STSE. The main conclusions of the study are as follows: (1) The content of STSE education is presented in the three sets of textbooks, but there are large differences in proportion of STSE content for three different science textbooks, namely, 42.1% of Science Explorer, 30.1% of Science and Technology, 27.1% of Science. (2) Considering the four field of science curriculum content based on the science curriculum standard, STSE mainly presented in the field of physical science and earth science, especially STSE accounting for more than 40% in the field of earth science in science textbook of USA and mainland. (3) When it refers to which aspects of STSE embodies most/least in textbooks, it shows that the percentage of "science and technology impact on the social environment" is the most stressed (more than 35% for three sets of textbooks) and the "influence of social environment on science and technology" showed the least. (4) Analyzing the ways of presentation, there are text, diagrams, physical map and tables, but the form of text is the most popular way of presentation. Suggestions on our science textbooks compilation, such as “the influence of the social environment of science and technology” acted as one STSE dimension is needed to be strengthen and the distribution of various indicators need to be a further balance. Other implications for our textbook compiling and STSE education in science teacher are discussed, such as the percent of STSE in the science inquiry can be appropriately increased.

[28O5D-3] What Major “Socio-Scientific Topics” Should Be Focused in Science Curriculum?: A Delphi Study of the Expert Community in China (*A0336*)

Yanlan Wan* and Hualin Bi

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ABSTRACT Science and technology play an important role in the development of human society. Thus, science education should reflect the trend of social development and prepare students to think about and make wise decisions on major social topics related to science. As an aspect of the societal dimension of science, socio-scientific topics(SST) have a great influence on social development. These topics not only represent the power and frontier areas which can promote the development of society, but also refer to the social acute questions in the process of developing and using science and technology, that is socio-scientific issues(SSI) focused by educational researchers in recent years. In order to prepare students to participate effectively in society both today and in future, shape their society in a sustainable way, and become responsible citizens, what major socio-scientific topics should the science curriculum relevant to students and the society focus? In this study, the famous future forecasting method——delphi method is used to explore the socio-scientific topics that science curriculum should prepare students to understand. 33 experts who come from Chinese institutions of higher education and scientific

research institutes are invited to make effective decisions based on the background of social development and students' all-round development demands. The results show that 7 level-one socio-scientific topics are received consensus and should be emphasized in science curriculum: environmental issues, ecological system, resources and energy, biotechnology, new materials, safety and health, and the nature of science. It is believed that the conclusion is helpful to promote the development of students' key competencies, and can provide advice and enlightenment for science curriculum reform.

[28O5D-4] Comparizon and Analysis of NOS in Science Textbooks of USA, Taiwan and Mainland, China (*A0596*)

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ABSTRACT The general goal of science curriculum is to improve students' scientific literacy, and the Nature of Science (NOS) as one of the core contents of scientific literacy has always been valued by the international science education, which is also reflected in Science Education Standards of most countries. Science textbooks play an important role of reflecting the contents of NOS, and the scientific contents and the forms of presentation affect the understanding of NOS. Thus, this study focus on the NOS comparison and analysis of three sets of science textbooks from different regions/countries. Using N.G.Lederman's NOS understanding, seven aspects which include "scientific knowledge is temporary", "science is based on evidence" ,"there is some subjectivity in science" and so on were used in the analysis. The contents of NOS and its way of presentation were analyzed and compared in three sets of textbooks, which are Science Explorer of America, Science and Technology of Taiwan and Science of mainland for junior school students. The quantitative analysis is given according to the units include the description of the dimensions of NOS. Some preliminary conclusions were drawn as follows: Firstly, the proportion of NOS shows nearly the same, namely, 35.90% of Science Explorer ,33.94% of Science and 30.16% of Science and Technology. Secondly, considering the different field of science curriculum, which include scientific inquiry, physical science, life science, earth and universe, the proportion of NOS in the field of physical science is nearly the same, namely, accounting for about 50% of three sets of science textbooks. While the percent of NOS in the field of scientific inquiry is significantly lower than other fields, accounting for less than 10%. Thirdly, the aspect of NOS, namely, "science is based on evidence" is most stressed in the textbook of mainland (nearly 50%), the proportion of other two aspects such as "creativity" and "distinguishing science theories and laws" are higher than 10% in three sets of textbooks. While the aspects of "temporality", "subjectivity" and "creativity" of textbooks in USA is much more than other two sets of textbooks. As main form of NOS presentation, accounting for nearly 90% of text used in Science Explorer, nearly above 75% of text used in other two textbooks. Some implications for our textbook compiling and NOS teaching are discussed. For example, the aspects of "temporality", "subjectivity" and "creativity" are important for students to understand. It is necessary to increase the percentage of these aspects in science textbook of mainland.

[28O5D-5] Analysis and Suggestion: Scientific Inquiry in Three Sets of Textbooks (*A0597*)

Zhifeng Wu* and Xiao Huang+

College of Teacher Education, Zhejiang Normal University, China Mainland

ABSTRACT As an important part of science teaching, scientific inquiry is not only included in countries' national curriculum standards, but also in different versions of science textbooks. As an essential carrier of scientific inquiry, the contents, and the ways to present the contents influence the achieving of the goal. The paper compared and analyzed scientific inquiry in three junior school science textbooks from different countries/districts. Based on the understanding of scientific inquiry which divided into full scientific inquiry and part scientific inquiry, five dimensions include posing questions, developing and using models, designing and conducting investigations, explaining and judging results, and the ways of expressing and communicating were used to analysis. Taking Science Explorer of America, Science and Technology of Taiwan and the Science of mainland as research objects. Scientific inquiry was analyzed quantitatively and qualitatively according to the types and levels of inquiry, the curriculum content, the indices of scientific inquiry dimensions, and the ways of presentation. We calculated the different units according to the paragraph/sentence include the description of scientific inquiry. The main conclusions were drawn as follows: (1)There are many scientific inquiry activities presented in the three sets of science teaching materials, showing the part scientific inquiry(nearly 71%) is much more than full scientific inquiry (nearly 28%) for three sets of textbooks. Further comparing the full scientific inquiry, Science and Technology of Taiwan is significantly more than other two sets textbooks (nearly 7.7% for United States, nearly 4.9% for Mainland). (2) The percentage of the scientific inquiry in the field of material science, life science, earth science is similar in the teaching materials of the United States, accounting for 33.40%, 29.02% and 33.40% respectively. Comparing the percent of scientific inquiry in different field, it showed that the proportion of scientific inquiry in the field of material science is greater than the other two areas in the teaching materials of Taiwan and Mainland, accounting for 65.56%, 50.38% respectively. Scientific inquiry as one part of the curriculum content (nearly 5%), the proportion was less than the previous three areas for all three sets of textbooks. (3) Question is important for scientific inquiry, and the importance of questions in scientific inquiry can be known from the analysis of three sets of textbooks, which showing nearly 38.5% of mainland, 40.8% of United States and Taiwan accounting for 50% respectively. Taking "the expression and communication" as an example, it shows that the percent of "the expression and communication" in Mainland is significantly higher than that of the United States, and Taiwan. (4) Scientific inquiry has different levels, namely, L4 and L5 can be regarded as the high level while L1 and L2 represent the low level. In the full scientific inquiry, the proportion of L4 and L5 level is the highest in the teaching materials of the Mainland (nearly 51%), the following is the United States (37%), and Taiwan is the lowest (nearly 19%). In the part scientific

inquiry, the Level 1 is higher than the level 2 in the three sets of the teaching materials, the lowest of the proportion of the level 1 accounts for 74.78%, and the highest of the proportion of the level 1 accounts for 25.23%. The level gap of the United States is less than Taiwan and Mainland China, but the gap is nearly 50% among them. Some implications for our textbook compiling and using in scientific inquiry teaching are discussed. For example, the beginning of scientific inquiry is to put forward questions, we should pay much attention to the importance of questions posing as well as the level of scientific inquiry.

[28O5D-6] Getting Students' Voices Heard in Sexuality Education: The Case of Implementing a Radio Drama in Hong Kong (*A0206*)

Chung Yiu Kay Wilson[†] and Yip Wing Yan Valerie*
Faculty of Education, The University of Hong Kong, Hong Kong

ABSTRACT The importance of sexuality education is to equip students with the knowledge and skills to make responsible choices in their lives. Effective sexuality education programmes have to provide students with the age-appropriate and culturally relevant information. Thus, listening to students' voices is essential. Student voices offer valuable insights into curricular improvement as they are in the best position to talk about the immediacy of their experiences. Nevertheless, it is not uncommon that students are usually kept silent. This phenomenon works against in developing effective sexuality education curricula with the interests of young people taken into account. To listen to students' voices, they should be provided with a safe learning space so as to freely express their concerns about sexuality issues. This study aims to elicit students' voices in the production of a school-based radio drama. While the junior secondary students and teacher produced and broadcasted the radio drama, both parties became action researchers who were deeply involved in reflecting upon their experience and modifying their plans. Based on the data, students generally agreed that they were the key stakeholder in sexuality education. However, even if multiple measures were adopted to establish a sense of safety, students existed signs of struggle that could be either intrapersonal (e.g. personality) or interpersonal. For instance, they could have personal discomfort when discussing sensitive issues at school. When they participated in the subsequent stages of programme, they refrained from voice-acting certain characters/episodes. Students felt unsafe as they worried about unforeseeable social consequences. This study suggested that interpersonal struggle (e.g. a negative comment from peers) is the most influential among students. The research also indicated that getting students' voices heard in school-based sexuality education is not as easy as it seems. Important measures have to be adopted to alleviate the possible struggles experienced by students. The research findings will also give educators insights into the future design of school-based sexuality programme.

<5E> STEM
Chairs: Harry Firman (Universitas Pendidikan Indonesia), Hyunju Lee (Ewha Womans University)

[28O5E-1] Bringing Up STEM Education: Enrich Science Learning Source based on STEM Approach (*A0534*)

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Universitas Pendidikan Indonesia (Indonesia University of Education), Indonesia

ABSTRACT Previous research result of challenges in implementing STEM Education in Indonesia showed that teachers face difficulties in developing STEM based learning because the lack of its learning sources. Therefore, we analyzed several content in middle school science learning and chose "simple machine" as the targeted topic to be enriched based on STEM approach. We decided to take three steps of enrichment processes; 1) crosscutting concept development, 2) learning source types design, and 3) learning source optimization. Analyzing the concept, and deciding the theme based on STEM was included into first step. Moreover, the design was adapted to the types of learning sources; handout, workbook, or e-book that was taken in second step. On the last step, it was tested to students to get information of its implication toward students' concept mastery, problem solving skills, and engineering design behavior. The samples of this research came from two different middle schools that implement different type of learning sources. The first sample consisted of 82 middle school students that divided into controlled and experiment group. They used handout of simple machine that impacted on their concept mastery and engineering design behavior. The second sample consisted 24 middle school students who used workbook of simple machine that impacted on their problem solving skills. Students' concept mastery were analyzed from concept mastery test result that consisted of 20 questions. Engineering design behavior was observed from the learning processes that categorized based on understand the challenge, build knowledge, generate ideas, and represent ideas. Problem solving skills were analyzed from students' skills on identifying problems, exploring problems, set goals, look at alternative, and select best solution indicators. The results showed that the enriched learning source based on STEM approach improved students' concept mastery that shown by normalized gain analysis result on <g> 0.72, developed students' engineering design behavior from beginning designer to informed designer, and increase students' problem skills (<g> = 0.45).

[28O5E-2] Impact of Non-formal Integrated STEM Education on Students' Interest towards STEM (*A0482*)

Edy Hafizan Mohd Shahali, Lilia Halim, Mohamad Sattar Rasul, and Mohd Afendi Zulkifeli
National University of Malaysia, Malaysia

ABSTRACT The purpose of this study was to identify students' changes of interest toward pursuing STEM career after participating in non-formal integrated STEM education programme named Bitara-STEM: Science of Smart Communities. The programme exposed students with integrated STEM education through project based learning involving the application of five phases engineering design process (ask, imagine, create, test and improve). 113 secondary school students were involved in this study. The study utilized one group quasi-experimental design. The analysis revealed that, overall there is a significant increase in mean scores for interest towards STEM career after

participating in the programme. Pre- and post-student responses were also matched and placed into one of nine response categories: remained high; remain moderate; remain low; high to moderate; high to low; moderate to high; moderate to low; low to high and low to moderate. The findings revealed that 42.62% of students who were at moderate level of interest towards STEM career prior to the program have changed to high level of interest after participating in the programme. The outcomes of this study provide evidence that a relatively short-term non-formal integrated STEM education programme can have a significant impact on participants' interest towards STEM careers. Further research should be studied to explore the reason for those changes. Understanding the factors involved will help further researchers improve and design programs that produce large positive changes on the variable being studied.

[28O5E-3] The Effect on Group Confidence and Self-confidence on Hands-on Making Technology Contest (*A0584*)

Jon-Chao Hong*, Chi-Ruei Tsai, and Kai-Wen Tai
National Taiwan Normal University, Taiwan

ABSTRACT A person who is being called mama's boy often regarded as who is excessively well-caring by their parents. A mama's boy might lose their chance to develop their independence and autonomous on daily life. In social interaction, they might be careless about other people, which might be a crisis when they have to cooperate with other people. Confidence is regarded as a belief that might effect on making a decision. To individual, one's self-confidence is a self-belief that he is capable of doing something. Otherwise, the group confidence focuses on how the group members have faith in each other. The previous studies showed that the group confidence belief might be categorized into group member's abilities, the reaction to the incidents, their own group and the perception of the opponent groups. In present study, we focus on the relationship between the perceptions of parental daily care, four types of group confidences and the self-confidence enhanced on hands-on making technology contest. The results showed that the perceptions of parental daily care is related to group confidence, the belief of group member's abilities and their own group are related to the confidence enhanced on hands-on making.

[28O5E-4] Integrated STEM Through Project Oriented Problem Based Learning (PoPBL) in Engineering Design Process (EDP)- Energy Module: Level of Scientific Creativity Among Students in Grade 2 (*A0589*)

Mohd Afendi Zulkifeli, Lilia Halim, Mohamad Sattar Rasul, and Edy Hafizan Mohd Shahali
National University of Malaysia, Malaysia

ABSTRACT Creativity is one of skills that is important to develop in science education. However, studies have shown that teachers have difficulty fostering students' creativity in the classroom. The purpose of this study was to identify the level of scientific creativity among students (13 and 14 years old) of different abilities after participating in an informal education programme called Bitara-STEM: Science of Smart Communities. Students undergo integrated STEM education through project oriented problem based learning (PoPBL) in six different modules. 30 secondary students (out of 150) that have been exposed to one of the module named EDP- Energy Module were involved in this study. The scientific creativity was measured through evaluating the science technical product (solar car model) produced by the participants. Ten criteria of scientific creativity (fluency, flexibility, unusualness, coherency, synthesis, simplicity, association, originality, elaboration, and value) were measured by using Science Technical Product Assessment Rubric. The assessment rubric classifies students' level of scientific creativity into low, moderate and high level. The findings of this study indicate that 38.34% of the students were at high level of scientific creativity, while majority of them (66.67%) were at moderate level. Furthermore, interview was also done to support the quantitative findings of each criteria of scientific creativity in this study. The findings of the study were discussed and provided information to further improve the effectiveness of the module used in this programme.

[28O5E-5] STEM Education in Secondary Schools in Sri Lanka: Trends and Challenges (*A0006*)

Aregamalage Sujeewa Vijayanthi Polgampala*, Hong Shen*, and Fang Huang*
Huazhong University of Science and Technology, China Mainland

ABSTRACT Salient feature of twenty-first century education is to bolster student engagement and drive more innovation for transformation of education. Learning becomes more authentic with blended approach as it is an umbrella for several important pedagogical strategies that have great potential to deeper learning approaches which connect curriculum to life outside the classroom to the real-world application. Fostering education and training in STEM ensures that today's students can generate and test new ideas and contribute to the scientific developments and innovations for tomorrow. Effective secondary education through STEM programs shares the elements of strong leadership, professional capacity of teachers, a student-centered learning climate, and instructional guidance for teachers. Out-of-class activities, a standard-based curriculum, and program sustainability are key characteristics as well. Sri Lanka is middle income developing country which pays prime concern for education and still at the conceived budding stage of STEM education. Consent to the aim and to celebrate this research was to understand the effectiveness in STEM programmes. The primary research tools were semi structured questionnaires, interviews and teaching practice observations of ten Sri Lankan prospective science teachers from a reputed National College of Education. Outcomes from this study showed that teacher's perception of STEM, their personal knowledge, and understanding of that knowledge, is intrinsically linked to the effectiveness of STEM delivery in their own classroom practice. Lack of technology, infrastructure facilities were the poignant factors exploited from the classroom observations of secondary schools STEM classes. It was also apparent that teachers with a strong capacity to teach in their discipline are essential for the success of any STEM practice. Expanding internship programs in particular for STEM disciplines provide work experience to students that would strengthen the relevance of higher education programs. Conclusions are drawn that highly-qualified STEM teachers

are still in high demand.

[28O5E-6] College Students' Conceptions of Nature of Technology (*A0207*)

Hyunok Lee* and Hyunju Lee+
Ewha Womans University, Korea

ABSTRACT Nature of technology (NOT) has long been recommended to be an integral part of scientific literacy and recently STEM-related initiative has asked to reconstruct standards of science education with inclusion of technology and engineering. Regarding this condition, it would be appropriate to start investigating students' conceptions about NOT, in a similar manner of early advances in research on nature of science (NOS). Conceptions about technology have been investigated and their major findings are summarized as followings. Most people tend to restrict technology to the final products and fail to appreciate its dimension of process or activities. In addition, there is a tendency that modern high technological artifacts are commonly referred as technical products such as computer and electronics rather than relatively simple and familiar objects such as pencils and reading glasses. In short, the empirical researches on conceptions about technology have shown that people have a tendency to define technology with a narrow meaning. However, the report that most students associated technology with a narrow and restricted meaning does not presume that they cannot elaborate coherently about their ideas about technology in contextualized probes. Most of the previous research had used simple questions such as "what is technology?" Hence, contextualized questionnaire about technology would give in-depth findings on students' conception about technology. This research adopted NOT questionnaire based on the authors' NOT conceptual framework. The NOT framework, a construct of balanced and informed explanations on technology, has a total of 12 components under four categories as various modes of manifestation in technology: 1) artifact, 2) practice, 3) knowledge and 4) system. The NOT were synthesized through consultation of invited experts in the fields of history, philosophy of technology and engineering as well as science educators based on an extensive literature review. The NOT questionnaire was developed based on its framework consisting of seven open-ended items by the two authors. The initial version was reviewed with three experts in science education and pretested with four college students in order to validate the questions and measure approximate response time. The participants were 28 college freshmen. They completed the NOT questionnaire and 12 students (40%) were interviewed in order to gather qualitative data more about their own understanding. The inductive method was utilized to analyze students' responses. For the result, it was found that the students conceptualized most NOT components with some differences in the level of understanding. In particular, NOT components under artifacts category, intentional artifacts, solution for real-world problems, positive and negative impacts of artifacts, were mentioned explicitly by most of students. NOT components under knowledge category, in contrast, were mentioned relatively less than the others. Some participants (41%) failed to articulate features of technological/engineering knowledge such as procedural knowledge, practical knowledge, context-dependent knowledge. The empirical result from students' responses of NOT questionnaire provides motivation for future research and directions about decisions in NOT implementation.

<5F> Historical/Philosophical/Sociological/Cultural/Gender Issues

Chairs: Shu-Fen Lin (National Changhua University of Education), Suhanna Binti Zainudin (Universiti Kebangsaan Malaysia)

[28O5F-1] High Order Thinking Skills: Preparation of Lesson Plan with Lesson Study Approach for Biology Subject (*A0371*)

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ABSTRACT High Order Thinking Skills (HOTS) is an essential skill to be mastered by students in preparing them of being competent in problem solving thinking. In order to achieve that, teachers need to be well prepared to integrate these skills in the classroom. Therefore, teachers need to plan collaboratively to create lesson plans that are integrated with appropriate thinking skills. Then, teachers need to be given observations, attention and reflection from other teachers to ensure that the process of thinking skills by students, run smoothly in class. Activity planning, observation and reflection for this collaborative approach can be executed through Lesson Study. Thus, this study explores how teachers integrate High Order Thinking Skills while planning their teaching. Studies conducted through observation, involving three biology teachers from the same school as the participants to discuss lesson plans for the subtopic; Mitosis. The topic is chosen due to level of difficulty to be understood by students. Students need to know how to differentiate the structure and the form of chromosomes for each phase in Mitosis. Moreover, students need to understand the applications of Mitosis in their daily life. This knowledge area entails students to think at a higher level while ensuring that they really understand and able to explore the process of Mitosis. This is better rather than simply memorizing terms and processes occurring in each phase of Mitosis as happened in the usual biology lesson in class. The study found a number of themes related to HOTS appear when teachers plan lessons collaboratively. Among the themes appeared; HOTS questions based on Bloom's Taxonomy, the ability of students to answer HOTS questions, 21st century approach to education as an incentive for students to think, and students' prior knowledge. Results from this study will guide the teachers, school administrators and policy makers in implementing the strategy advocated to HOTS in the process of teaching and learning. Lesson Study can be used as an approach to improve skills, knowledge and confidence related to teaching especially implementing HOTS in classroom. The findings of this study can help teachers individually or in groups to design lesson plans inculcated with HOTS.

[28O5F-2] Design a Teacher Facilitation Program to Improve College Teachers' Professional Development in Science Teaching (*A0488*)

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ABSTRACT Teachers' pedagogical content knowledge (PCK) dominates their instructional design, how they manage the class, and how they teach students. The purpose of this study was to design a Teacher Facilitation Program (TFP) with PCK framework to improve college teachers' professional development in science teaching. Teachers can find methods of using pre-instructional strategies, designing of curriculum and assignments, evaluation and so on to improve teaching for their classes. Seventeen science teachers with low teachers' pedagogical assessment in the first semester were selected to participate in the TFP. After a semester, the teachers' pedagogical assessment results which scored by students were collected and analyzed. The finding showed that the TFP could be useful in helping teachers to improve their pedagogical content knowledge. In addition, the teachers' attitude toward teaching was significantly improved after a semester TFP training. Moreover, the scores of teachers' pedagogical assessment were improved as compared to the previous assessment. On the basis of our findings, we also proposed suggestions for future teachers' professional development in science teaching research.

[28O5F-3] Elementary School Teachers Motivation and Difficulties Met in the Implementation of Lesson Study (*A0576*)

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ABSTRACT Lesson study had already gained wide recognition. There are three pathways, according to Lewis, Perry and Hurd (2009) through which lesson study improves instruction: changes in teachers' knowledge and beliefs; changes in professional community; and changes in teaching–learning resources. The Oton District of Department of Education in the Philippines, a district with 16 elementary schools, aimed to institutionalize this practice. Trainings and follow-up observations were made through the efforts of the University of the Philippines, a certain private corporate partner, local government unit of Oton and Department of Education. However, the initial effort involved only about 100 teachers, principals and knowledgeable others. To encourage more teachers to participate as well as to attain sustainable practice of lesson study in the district, possible deterrents must be identified and be addressed; motivations and enablers should be amplified; and misconceptions by stakeholders should be clarified. This study determined the teachers motivation in doing lesson study; difficulties encountered; their apprehension, fears or misgivings; and lastly their opinion about the lesson study in general. The respondent teachers had average age of 43, all were female, and more than 75% of them taught more than one subject. Specifically, 41 taught mathematics and 23 taught science. To gather the data, the respondents were asked to answer a questionnaire that ask them about their personal data as well as their motivation, difficulties met, fear and apprehensions as well as their general opinion about lesson study. Further clarifications were then made through in depth interview. Thematic data analysis was then used to analyse the data. The presentation will discuss the results of this inquiry as well as the solutions and policy that will be appropriate to achieve the institutionalization of the lesson study in the district.

[28O5F-4] Validation of an Instrument and Exploring for Assessing Science Teachers' Views of Inquiry Teaching (*A0185*)

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ABSTRACT The purposes of this study were to develop and validate an instrument that assesses science teachers' views of inquiry teaching (VOIT) and to conduct a pilot study for exploring junior high school science teachers' views of inquiry teaching in mid-Taiwan. The theoretical framework of VOIT questionnaire was based on the study of core teaching conceptions on teachers' use of inquiry teaching practices (Lotter, Harwood, & Bonner, 2007). The VOIT questionnaire was composed of four dimensions which guided teachers' use of inquiry teaching practices, including teachers' views of science, their students, effective teaching practices, and the purpose of education. Each dimension contained a pair of opposing positions that teachers do not intend and support inquiry teaching. For example, the dimension of teachers' views of science contained addressing a set of knowledge and science process skill. The dimension of purpose of education contained obtaining a mass of information and developing problem-solving skills for schooling goals or future life. The dimension of teachers' views of their students contained viewing students as passive learners with limited ability and viewing students as evolving problem solvers who needed practice to expand ability. The dimension of teachers' views of effective teaching contained transmitting knowledge and encouraging independent thought. After item analysis and exploratory factor analysis, 34 Likert-type items were selected for the VOIT questionnaire. The instrument composed of eight scales, including knowledge (4 items) and process (4 items) regarding views of science, acquiring a mass of information (5 items) and developing problem-solving skills (5 items) regarding purpose of education, limited ability (4 items) and expanding ability (4 items) regarding views of students, as well as transmitting knowledge (4 items) and encouraging independent thought (4 items) regarding views of effective teaching. The feature of equal amounts of items in the opposing scales of each dimension would assess teachers' views of inquiry validly. The Cronbach's alpha coefficient for the VOIT questionnaire was 0.87 and that for each scale ranged from 0.73 to 0.84. A total of 63.0% variance was explained by the eight factors. In a pilot study, 319 science teachers in junior high schools from different districts and school sizes in mid-Taiwan were selected to respond the VOIT questionnaire. The descriptive analysis of the VOIT responses (e.g. mean scores, skewness and kurtosis) were used to explore teachers' core views impacting their intention of inquiry teaching. Results indicated that teachers tended to possess some supportive views of inquiry teaching (M=3.60, SD=0.37). Especially teachers emphasized to foster students' process skills, problem-solving skills and students' independent thinking more than to obtain a set of knowledge and adopt knowledge transmitting model. However, a majority of teachers still addressed the importance of obtaining a mass

of information for the purpose of education. In brief, the view of obtaining a mass of information could be the most obstacles to hinder teachers' implement of inquiry teaching.

[28O5F-5] The Research on Pre-service Chemistry Teachers' PCK Development by Case of Micro Teaching Curriculum (*A0581*)

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ABSTRACT Based on a systematic study of the pedagogical content knowledge (PCK) theory, this paper puts forward an idea that chemistry teachers' PCK mainly composed of three elements: teaching content knowledge, student knowledge and teaching strategy knowledge, and constructs a PCK performance progression theory model which includes all three elements above of the chemistry teachers. In order to investigate the current development situation of the pre-service chemistry teachers' PCK, the authors compiled a performance progression evaluation tool for chemistry teacher on the basis of the PCK performance progression model. Taking the simulate teaching practice performance of the pre-service chemistry teachers in "high school chemistry micro teach-ing" curriculum as an example with the application of methods of classroom observation, text analysis and video analysis to study the PCK development of 36 senior students in College of Chemistry, Central China Normal University, the paper reveals the main problem in pre-service chemistry teachers' PCK development and the main factors which affect it. Against the main problem, the researchers designed and implemented an intervention tasks to improve PCK devel-opment which showed by study that these tasks can effectively improve the level of the pre-service chemistry teachers. Another study of this paper analysis micro-standard teaching video of pre-service teachers who teach without the intervention through PCK theory, and it is concluded the status of the PCK of pre-service teachers. We also found out that there are changes in the PCK after intervention added and micro-standard teaching course have a sufficient influence on the pre-service teachers' develop-ment of PCK which proves the necessity of university micro teaching curriculum.

<5G> Learners (Curriculum/Teaching Materials)

Chairs: Pei-Chi Chen (National Taiwan Normal University), Cindy Chyee Chen Wong (The National University of Malaysia)

[28O5G-1] 11th Graders' Problem-solving Performances, Self-efficiency and Perceptions about Physics Problems with Different Representational Formats (*A0149*)

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ABSTRACT Numerical and symbolic representations are used extensively in presenting physics problems. However, little is understood about how students respond to different representational formats while solving problems. The purpose of this study thus was to explore and compare 11th graders' problem solving performances, self-efficiency and perceptions about isomorphic physics problems posed in numerical and symbolic formats. The problems involved basic concepts of Newtonian mechanics. In the first stage, our participants were 108 11th graders' who were taking a basic physics course and randomly assigned to solve problems in either a numerical or symbolic format. The results of statistical analysis showed that performances of the numerical group were significantly superior to those of the symbolic group ($p < .001$), but there was no difference in students' self-efficiency on solving problems between the two groups. Then students were divided into high-, medium-, and low-achieving sub-groups differentiated by their problem-solving performances. In the second stage, six students from each group were asked to solve physics problems in another format and interviewed afterward. Students' interview responses and the problem-solving steps they took were analyzed. We found that for the majority of students, solving symbolic physics problems was more difficult than numerical ones across steps. The differences between students' performances in the two formats were enlarging through the problem-solving process. There was no significant difference in the first step - describing the physics ($\chi^2 = 3.696$, $p = .30$) and the second step -planning the solution ($\chi^2 = 6.473$, $p = .09$), but a significant difference existed in the third step - solving equations and evaluating the solution ($\chi^2 = 14.131$, $p < .01$). Additionally, in the second ($\chi^2 = 10.036$, $p < .05$) and the third problem- solving steps ($\chi^2 = 11.143$, $p < .01$), high-achieving students' performances on problems in the numerical format were significantly better than those on problems in the symbolic format. For low- achieving students, no significant differences were observed in their performances between the two formats in the first and second steps, but their performances on the numerical format remained markedly superior to those on the symbolic format in the third step ($\chi^2 = 6.982$, $p < .05$). Furthermore, students had more positive perceptions about problems in the numerical format; they spent less time and were more willing to solve them. However, while solving symbolic problems, they encountered more difficulties in calculating and evaluating the solution, and were confused about the meaning of symbols. The findings suggest that when teachers introduce new physics concepts or develop assessments, they may need to select or arrange appropriate representations, provide timing scaffolds, and establish meaningful links between numbers and symbols to meet students' needs.

[28O5G-2] Exploring the Misconceptions of Students (*A0305*)

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ABSTRACT Misconception is present in the students' mind which is different with scientific conception and formed by the daily experience, social media, classroom teaching and so on. Some misconception is consistent with the scientific conception, it' s the basis of students get the scientific conception. But most misconception is completely opposite with scientific conception, so it' s a stumbling block to the formation of scientific conception. Therefore, grasp the students' misconception is particularly important. Vessels are the foundation of biology important conception of our junior high school. In this study, we put vessel as an example, explore students' misconception, in order to provide theoretical support and practical feasibility support for the research of misconception, and provide a

reference for teachers effective teaching. The problem of this study is focus on three aspects:1. Combing scientific conceptions of vessel. In order to in-depth explore the misconception for students, we refine the scientific conception and characterize the scientific conception combine with the construction of the model.2. Preparation of Interview tools. Through the pre-interview preliminarily grasp the misconception which the students' have. Prepare the Interview tools on the basis of collection and analysis of the data.3. Grasp the misconception of students. Use the interview tool do some communicate with junior high school students, then analyze the results of interviews and get the conclusion. To solve the above research questions, this study has done the following work：(1) Determine the scientific concept of blood vessels. According to China junior high school biology textbooks (Beijing Normal University) and junior high school biology textbook (PEP) to tease out the scientific concept of blood vessels, and divided it into four sub-concepts: arteries, capillaries, veins, venous limbs, followed by coded as A, B, C, D. Then based on the concept teaching' five elements (words, connotation, extension, instances, misconception) , divided the sub-concepts into seven elements , they are "words", "structure", "function", "distribution", "instance", "external relations", "internal relations", followed by coded as "a", "b", "c", "d" , "e", "f", "g". Through the 4 sub-concepts and the 7 elements, and the concept of scientific vessel concept is divided into 25 fragments of scientific concepts. Combining the 25 fragments of scientific concepts and vascular distribution diagram, and represent the concept of vessels with images and text. (2) Preparation of interview tool. According to the 25 fragments of scientific concepts, the research prepare the pre-interview outline. Each fragment of scientific concept corresponding to the 1-2 interview questions, and interview outline includes 33 pre-interview questions. Use the pre-interview outline to interview the 8 grades students in Chengdu. According to the results of pre-interview and reference the students' may answer, scheduling the interviews questions and making the road map of interview as the formal interview tool ,in order to in-depth explore the students' misconception. (3) Explore the students' misconception. Interview the 8th grade students in Chengdu with the formal interview tool. According the results of the interview, do some text analysis. Then explore the association among the misconceptions in students with SPSS software. The conclusion of the study: 1 .In this study, we divided the scientific conception of vessel into 25 fragments of scientific concepts through the 4 sub-concepts and 7 elements, and change the abstract, complex scientific concepts to visual and simple scientific concepts. It' s will advantage for students construct the scientific conception. 2. Students have the misconceptions of vessel, which are come from daily experience, social media, classroom teaching and so on. 3.There are relevance among the students' misconceptions.

[28O5G-3] The Effects of Learning Outside the Classroom (LOC) Science Module on Academic Achievement and Intrinsic Motivation of Marginalized Learners in Malaysia (*A0348*)

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ABSTRACT In the knowledge-based society of the 21st century where information is rapidly changed, marginalized learners need to upgrade themselves through school education in order to prepare for new era society. Marginalized learners can learn more meaningfully when the learning process takes place in the conducive and comfortable environment. This study aimed to determine the effects of the Learning Outside the Classroom (LOC) module on academic achievement and intrinsic motivation of marginalized learners in learning science. In this study, intrinsic motivation refers to feeling of fun in the learning process and the enjoyment of an activity in the area of science and general academic content. For that, quasi-experimental design with pre-test post-test, nonequivalent control group research design was implemented. A total of 73 primary school learners from four schools in the interior part of Sarawak sampled in this study. The experimental group (n=38) used LOC module while the control group (n=35) used conventional method in teaching science. Academic achievement evaluates using Achievement Test (AT) whereas intrinsic motivation evaluates using Intrinsic Motivation Questionnaire (IMQ). Both instruments were administered before and after the intervention to both groups. Data obtained from AT and IMQ were analyzed using Independent-sample T-test and MANOVA repeated measures. The results showed non-significant increase in AT mean scores in the experimental group. The findings also indicate that there is no significant main effect and interaction effect between group and time toward intrinsic motivation. As a result, the two teaching methods do not have significant and positive impact on intrinsic motivation among marginalized learners.

[28O5G-4] Development of the Science Test to Measure Higher Order Thinking Skills to Indonesia Secondary School Students (*A0384*)

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ABSTRACT One of Indonesian science educational goal is to improve student quality through developing Higher Order Thinking Skills (HOTS) since early age as basic skills for daily life, apart from the academic achievement in the schools. However, the concern fact is Indonesian students always got low rank and score in International studies. TIMSS result revealed that Indonesian students' performed lower than the international average benchmarking in all cognitive domains, mainly in reasoning domain which involve analyze, evaluate and create, key aspects of HOTS. Indonesian students' reasoning domain score was 20% while international average was 33% in TIMSS 2011 result. It is due to assessment in Indonesia including national examination mostly measures the knowledge dimension until level C3 (applying) especially in elementary and junior high school and non-linier with TIMSS cognitive domain. Thus, Indonesia students tend just being able to memorized content, memorized formula or method, and complex computing that it is not sufficient to face the real problem in their daily life. Whereas, assessment can be implemented to help student on improving theirs HOTS. Thus, the intention of this study was to assess the classification of science test items of TIMSS grade 8 based on HOTS and determine whether those classified-science test items can be an

assessment tool in science class. In order to measure that, the 37 reasoning items of TIMSS 1999, 2003, and 2011 was organized; then it was classified into analyzing, evaluating, and creating level of HOTS by table of HOT's component term of Krathwohl. Then, two items were randomly selected from each science subject (Life Science, Physics, and Chemistry) and level of HOTS item. Total sample test items of HOTS were 16; which were 6 of analyzing, 6 of evaluating, and 4 of creating, respectively. The selected items were tested to 410 of Grade 9 students in 14 schools in Jember, East Java-Indonesia. Data was analyzed by using point biserial correlation to measure index of discrimination and degree of difficulty at items of each level of HOTS test. The result revealed that the point biserial index of discrimination for each item on analyzing, evaluating and creating were higher than rtable (0.13) and significant at the 0.01 levels. It means the category of test items was correct in each group level of HOTS. The degree of difficulty of analyzing, evaluating and creating test items exhibited similar trend, which were in the range 0.2 to 0.5 (good) of difficulty index. Whilst reliability analysis showed that the total of Cronbach's alpha value of analyzing, evaluating and creating are more than 0.6 which is acceptable and indicating a high level of internal consistency. In conclusion, the classified science test items of TIMSS are good to use as assessment tools to measure HOTS of students in science class.

[28O5G-5] A Novel Teaching Approach Based on a DNA Experiment Lesson in High School Biology Laboratory Class: Scientific Inquiry by Visualization of DNA Sequence Conservation and Diversity and a Developmental Lesson to Understand Genetic Diagnosis (*A0415*)

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ABSTRACT Molecular biology has recently become a center of learning contents in high school biology. In modern society such molecular biology techniques are used for clinical diagnosis and personal identification tools for victims in various disasters and in criminal investigations. Therefore, high school biology is directly connected to modern biology based on molecular science. However, due to a scarcity of suitable teaching materials on molecular biology in high school biology laboratory classes, most of the students hardly have an opportunity to learn adequately. Here we developed a novel teaching material to help high school students understand molecular biology by performing a lesson on genetic and prenatal diagnosis based on the DNA experiment and then analyzing changes found in the students' pre- and post-questionnaires and -tests. First, we developed a DNA experiment to detect the conservation and/or diversity of DNA sequences among species. We focused on the SOX2 gene because it was well conserved among species. The conserved DNA sequences of the SOX2 gene between human and zebrafish were amplified from both their genomic DNA by PCR using the same sets of primers. PCR products were subjected to restriction enzyme digestion and then analyzed by a gel-electrophoresis. Second, we performed a two-day biology lesson during spring vacation, based on "science for all". A total of 29 students took part in this experiment; 12 first-year students and 17 second-year students. On the first day students spent 7 hours doing an experiment in groups with 3 teaching assistants. I explained the following contents; DNA formation and characteristics, central dogma, the difference between gene and genome and DNA, PCR and restriction enzyme reaction, the principle of a gel-electrophoresis during the experiment. The next morning, the students summarized and considered their experiment, and had group discussions, and then each group leader presented their analysis in front of the class. After the presentation they listened to a lecture on hereditary diversity in twins and clones by a university teacher, followed by a card game to recognize diversity. In the afternoon the students listened to two lectures on prenatal and genetic diagnosis given by medical staff, after the lectures they were given 20 minutes to discuss two case studies related to genetic diagnosis for early-onset Alzheimer disease and prenatal diagnosis. By comparing the students' evaluation, we could clarify the following; 1. The students' understanding resulted in qualitative change from macro to molecular points of view. 2. The data allowed the students to understand the reason why some control experiments were made by PCR and restriction enzyme digestion reaction. Moreover, they found out that the identical method of DNA analysis can be applied to each species to detect DNA sequence diversity. 3. The students recognized the benefits and the limitations of genetic and prenatal diagnosis, and realized the importance of DNA analysis in their future. In conclusion, our teaching material based on a DNA experiment resulted in a more advanced scientific inquiry, and the challenging discussion topics assisted high school students to a better understanding of molecular biology.

[28O5G-6] An Exploration of Game-based Learning in Senior High School Chemistry Classroom (*A0470*)

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ABSTRACT The concept of chemical reaction is one basic but crucial topic to learn chemistry. However, its complexity has frightened and frustrated students while learning with it. Game-based learning has been widely adopted in the recent years in various subjects of learning. The current study sought to observe how student learn while utilizing one developed chemistry card game with learning with chemical reaction. 75 10th-graders enrolled in one senior high school in northern Taiwan participated in the current study. In order to better understand how students reacted with the instruction, both qualitative (e.g., student interview) and quantitative data (e.g., pre- and post-Students' Motivation Toward Science Learning, SMTSL) were collected. In addition, the participants' background information, such as gender and academic performance in chemistry, were recorded as well. The analysis of the interview results appeared two significant improvements: confidence and engagement (e.g., in team collaboration and

oral presentation). Furthermore, the result of SMTSL showed a significant improvement on one of the 6 dimensions, Learning Environment Stimulation (LES), among others (e.g., Active Learning Strategies (ALS), Science Learning Value(SLV), Performance Goal (PG), and Achievement Goal (AG)). The findings of the current study suggest that the integration of game-based learning (card game) into the learning of chemical reaction may improve student's level of motivation, confidence and engagement. Further discussion will be included in the final presentation.

<5H> Teaching/Learning

Chairs: Heui-Baik Kim (Seoul National University), Lay Hoon Seah (Nanyang Technological University/National Institute of Education)

[28O5H-1] Features of Science Core Schools (SCSs) in Korea as Strategic Community of Practice (SCoP) (*A0288*)

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ABSTRACT With an increasing attention on social interaction and aspects of learning process, the Communities of Practice (CoP) is becoming a new conceptual framework in educational research. In its early stage, the theory of CoP presupposed spontaneity and informality for its formation. But, since schools in which most learning occurs are not spontaneously formed CoP, we need to apply the concept of Strategic Community of practice (SCoP) in order to understand actual features of CoP implemented in the school context. This study aimed to find out the features of Science Core Schools (SCSs) in Korea as SCoP and to discuss its implications to science education. In SCSs, while during the 1st year all students study along the same curriculum, during the 2nd and 3rd years students are belonged to one of the three types of class (i.e. Science core class, Humanity class, and Nature class) and study accordingly. A total of 1,648 students from 42 classes out of 14 high performing SCSs were selected for this study. To check the features of SCoP, the Science Classroom as Community of Practice (SCaCoP: Chun, Na, Joung, & Song 2015) questionnaire was applied to the students. In addition, the curricula and yearbooks of the SCSs since 2011 were collected and analyzed. The results of the analyses show that Science Core Classes had more curriculum asking students' active participation, such as 'research project', 'hands-on science activity', 'science lab class'. In addition, the scores of the all five factors (i.e. Responsibility for learning, Common interest, Mutual relationship, Open participation, and Practice) of SCaCop of the Science core class were significantly higher than those in the Humanity class and the Nature class. In this study, through the case of SCSs in Korea, it was possible to identify the educational potential and values of SCoP in actual schools.

[28O5H-2] Probing Into Experiment Classes of High-School Level Organic Chemistry: Take Silver Mirror Reaction as An Example (*A0578*)

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ABSTRACT Organic chemistry is regarded as one of the most challenging course in high schools. As a crucial part of science education, experimental classes occupy a significant position in high-school level science curriculum as well (Garnett, & Hacking, 1995; Hofstein & Lunetta, 2004; Hofstein, 2007). However, the teaching value of experiment classes of organic chemistry in high school has not been fully excavated, a connection between organic chemistry and other content has not been solidly established (Slocum & Jacobson, 2010). In this study, we analyzed the teaching value of high school organic chemistry experiments based on a case study of silver mirror reaction, and sought to find potential enlightenment on teaching. Methods of content analysis of textbooks, classroom observation, semi-structure interview with high school teachers were carried out. We analyzed the presentation of silver mirror reaction in two main versions of chemistry textbooks from China. The analysis was framed by three questions: 1) How is the reaction introduced? How is the reaction valued in terms of STS (science, technology and society)? 2) How is the reaction conducted? What is the hidden information behind experimental conditions? 3) How is the experiment observed and recorded? How is the abnormal phenomenon explained? In addition, classroom observation and semi-structured interviews with two 11th grade teachers are conducted in a public high school as well. Preliminary findings are as follows: 1) the introduction of silver mirror reaction is limited to the experiment itself, instead of a combination of technologies of industrial production; 2) the experimental conditions of silver mirror reaction indicate the strict conditions of crystal formation, which is not shown specific in textbook nor understood thoroughly by teachers; 3) students can not explain abnormal phenomena through combining other knowledge besides organic chemistry. Analysis of teaching value of the organic experiment contributes to better experimental teaching; advice and reference in teachers' organic experimental teaching will be given in future study.

[28O5H-3] The Knowledge Domains of Students React to Teacher's Questioning through Classroom Discourse (*A0313*)

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ABSTRACT This study investigated the knowledge domains of students during teachers questioning in the class. In other words, this study tried to know how the teacher's questions related to the knowledge levels of the student reaction. The present study was also part of the East Asian Studies which lead by Professor Yoshida. The questions that teachers asked were analyzed based on the cognitive domains of what students might do. The cognitive domains are remembering, understanding, applying, analyzing, evaluating, and creating. The knowledge domains are factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge (Anderson, & Krathwohl, 2001). Methods used in this study were mainly qualitative. Data collection was based on the observation of classroom teaching and the transcript of classroom discourse from digital video. One elementary science class and one junior high school science class had been observed. The elementary school is located in Taoyuan County, and the junior high school is located in Hsinchu City. The elementary science teacher had his bachelor and

master degrees in science education, and has taught science for 6 years. The junior high school science teacher also has her bachelor and master degrees in science education, and has taught science for 10 years. Content of grade 4 science is "Electric Circuit", and content of grade 9 science is "Electric current". The findings of this study were students in junior high school had more opportunities to respond the metacognitive knowledge, while students in elementary level also had lots of metacognitive knowledge when the teacher asked them to evaluate their own and other students' work. In addition, students in elementary school tended to have more factual and conceptual knowledge. The teacher of junior high school used a series of questions challenging students' thinking, she also asked a lot of guessing, and provides examples. However, the experiment work were followed the teacher's guidance step by step. As to the elementary level, the teacher used a lot of examples in daily life, the teacher did not easily provide answers to students, he asked questions to lead student thinking, after a period of time, and the teacher concluded the previous discussion of students. The teacher also motivated students a lot by encouraging and praising student answers. The teacher of elementary school did not ask student to follow his guidance to do the experiment, and he asked students to evaluate their own work and other students' work after the experiment.

[28O5H-4] Responsive Teaching Activating Students' Epistemological Resources in Small Group Argumentation (*A0200*)

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ABSTRACT This study aimed to understand how responsive teaching activates students' epistemological resources. The study's participants were 53 students in two eighth-grade classes and one teacher at a middle school. During five lessons from a "stimulus and reaction" chapter (each lesson containing an argumentation activity) students were divided into groups, developed a group argument, and then engaged in a whole-class argumentation. We chose one group that showed active engagement with the teacher as a focal group. We performed a collaborative reflection with both groups and the teacher to understand their discourse and behavior. The classroom discourses and collaborative reflection were transcribed and used for our analysis along with the worksheets completed by the students. The analysis showed that responsive teaching varied depending on whether or not students asked for the teacher's help. When students asked for help, the teacher elicited student responses by moves requesting confirmation about what exercise question in the worksheet was in order to figure out their problem. Next, she reframed the question and requested elaboration based on her interpretation of the students' response, thereby activating their epistemological resources for productive practice. When the teacher interpreted that conceptual confusion was the primary reason for the impasse during practice, she restated the question and requested clarification to change the students' practice to meaning-making. Meanwhile, the teacher also provided support to students who did not ask for help when she noticed that they were not able to begin the practice, interpreting this to mean that they were having difficulty connecting the provided data with a scientific idea. Since the teacher didn't have sufficient information about what kind of support the students needed, she tried various epistemological moves for scaffolding. Despite of the task's difficulty, students' productive argumentation was elicited after a short period of pause. Based on these findings, this study argues that a teacher's interpretation of students' practice affects the teacher's epistemological moves, altering the epistemological resources activated by students and, eventually, small group's argumentation practice. This study contributes to laying the groundwork for teacher's responsive teaching to foster productive small group argumentation practice.

[28O5H-5] Examining the Role of Talk in Addressing the Language Demands of Science: Case Studies of 3 Secondary Teachers (*A0362*)

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ABSTRACT Research on disciplinary language and literacy has highlighted the differences that exist between scientific language and language used in other school disciplines and in everyday life. The distinctive linguistic features, norms, conventions, genres and structures that characterize scientific language could present significant learning demands on students. Despite the recognition of these language demands, little is known about the kinds of language demands that teachers attend to in science classrooms. This case study of three secondary science teachers seeks to examine the role of classroom talk in addressing the language demands inherent in the topic on 'Human circulatory system'. Lesson transcripts of the entire lesson sequences on the topic from three secondary 3 classrooms constitute the data for this study. The data are analyzed using the "Addressing the language demands in science' (ALDIS) framework developed from an earlier study. This framework comprises 7 categories, including labelling, explaining, differentiating, selecting, constructing, deconstructing and pronouncing, which identify the functions of the teacher's talk in highlighting particular aspects of the scientific language that require students' attention. Using this framework, similarities and differences in the extent and ways in which the 3 teachers sought to address explicitly the language demands of science through talk are identified. The analysis also reveals the kinds of language demands inherent in the topic as well as the differences in the teaching focus of the individual teachers. The findings of this study have implications on the ways language demands in science can be addressed and the kind of professional development support that teachers would need to do so.

<5I> Curriculum/Assessment/Policy (Learners)

Chairs: Yew Jin Lee (Nanyang Technological University), Ying Luo (Beijing Normal University)

[28O5I-1] Analyzing Cognitive Levels of Learning Objectives in Elementary Science Curriculum in East-Asian Countries (*A0025*)

Yew-Jin Lee[1], Mijung Kim*+2, Qingna Jin[2]*, Hye-Gyoung Yoon[3], and Kenji Matsubara*[4]
1. Nanyang Technological University, Singapore, 2. University of Alberta,

Canada, 3. Chuncheon National University of Education, Korea, and 4. National Institute for Educational Policy Research (NIER), Japan

ABSTRACT The current study looks into the cognitive dimensions of learning objectives in elementary science curriculum in 6 different states in East-Asian region; China, Hong Kong, Japan, Korea, Singapore and Taiwan. We analyzed the levels of cognitive dimensions of learning objectives in science curriculum each state based on Revised Bloom's Taxonomy. The findings indicate that the cognitive level of Remember was highly represented in three states (China, Hong Kong, and Singapore) and the level of Understand was popular in most states except Japan. In Japanese science curriculum, nearly every learning objective was located in the domain of Apply, which paralleled the strong emphasis on applied knowledge of science during classroom teaching and learning. Korea too recently reformed elementary science curriculum with an emphasis of hands-on activities, thus, about 62% of learning objectives were located in this domain. Higher order thinking skills on Bloom's Taxonomy; Analyze, Evaluate, and Create were less than 5 % of learning objectives in all of the states. Factual and conceptual knowledge dimensions were common in most of the state and Procedural knowledge was dominant in Japan whereas metacognitive knowledge was hardly seen in any of science curricula. The challenges of analyzing learning objectives with Bloom's Taxonomy that were experienced by the researchers will be also discussed.

[28O5I-2] Does Peer Assessment Help Students' Understanding? (*A0091*)

Florence Le Hebel*[+1], Pascale Montpied[2], and Marianne Moulin[2]

1. University of Lyon, 2. Laboratoire ICAR, CNRS, Ens LYON, University of Lyon, France

ABSTRACT As a part of the European research project ASSIST-ME (Assess Inquiry in Science, Technology and Mathematics Education), our work investigates formative assessment methods in Sciences education. Based on literature (Bell and Cowie, 2001; Duschl, 2003), our definition of formative assessment involves three phases: gathering information about students' learning, interpreting those information and acting on it to improve student's learning. These phases can be made either by the teacher and/or a peer. The main point in formative assessment is to offer opportunity and/or guidance to students to improve their work and enhance their competencies. Among several methods of formative assessment, our study focuses on peer-assessment. The aim of our work is to measure the influence of peer assessment on student's understanding. In our study, peer feedback implementation is conducted in physics and geosciences and focuses on investigation competence. One of research question is: Do the students become aware of their own understanding while correcting their peer production? As part of ASSIST-ME overall research plan, we engaged 340 secondary level students (grade 10) in a teaching sequence for experimental science (physics or geo-sciences). At some point of the teaching sequence, the students work in pairs on an investigation-based activity and had to produce a written report. The same students pair had to examine afterwards the written productions of another group of the class thanks to a structured template that researchers previously build. In this study, we focus our analysis on a geo-sciences investigation-based activity. This activity based on an analogical modelling of an oil trap, is included in a teaching sequence about fossil energies. Students have to answer the problem: what are the necessary geological characteristics for an oil deposit to be exploitable? Then, they complete an assessment template, focusing on the ability of the peer-assessed to interpret and conclude to empirical observations. We gathered data in six 10-grade classes, involving 141 students. We video-recorded the teaching sequences, audio-recorded two-students teams and collected written production of each student. After the teaching sequence, we proceeded to 12 interviews of students in order to have their feedback about peer assessment. Our methodology of analysis consists of two steps: First, we examine all students' productions to identify the different categories of misunderstanding of the activity. When a misunderstanding is identified in the production of a pair of students, we examine the peers' production they assess and analyse the oral interactions that occurred during this assessment. Our aim is to find if there are some evidences showing if they become aware or not of their own misunderstanding while assessing peers who did not make the same mistake. Students' interviews analysis helps us to specify the role and the limits of peer assessment on their understanding. First results indicate that peer assessment may not help understanding for a part of students. We will discuss the specific conditions for which it might be helpful for students' understanding. It leads us to build new assessment templates, linking the assessed criteria and the correct answer of the task provided to the students when they assess their peers.

[28O5I-3] Assessment on Senior Secondary School Students' Learning Progression of Galvanic Cell (*A0116*)

Fan Shi* and Lei Wang[+]

Beijing Normal University, Beijing, China Mainland

ABSTRACT Galvanic cell is an important part of high school chemistry learning. There have been a lot of studies have shown that there were many misconceptions and difficulties encountered by students in learning galvanic cell (Gaarnet & Treagust,1992; Sanger & Greenbowe, 1997; Schmidt & Marohn, 2007; Rahayu, 2011). Learning progressions offer a model for educators of the paths by which learning might proceed within a domain. Although there is a growing body of research around learning progression, there has been little focus on developing a learning progression for galvanic cell in chemistry curriculum in high school. Hence, the study aims to evaluate students' progressions of galvanic cell to know: students' learning progression and how to improve teaching according to the results of the assessment. Based on the existing research of Electrochemistry Cognitive Mode, We built a hypothetical learning progression of galvanic cell with three progress variables: Key Ability Type, Problem Situation Difficulty and Cognitive Pattern. Key Ability Type includes understand (recognize, generalize and argue), apply (explain, predict and design) and create (complex reasoning, systematic inquiry and creative thinking). Problem Situation Difficulty includes familiar prototype, simple variant and complex-unfamiliar. The Cognitive Pattern includes the amount of Cognitive Perspective (single-Perspective or multi-Perspectives), initiative to use

Cognitive Perspective (passive/semi-autonomous/ autonomous) and complexity of Cognitive Perspective (isolated/associated/systemic). Based on those progress variables, 8 levels of hypothetical LPs in the galvanic cell have been proposed. We choose six test time nodes: before and after grade 10 to 12 galvanic cell teaching. About 3500 students were involved in the large scale paper and pencil test and 45 students participated in the interview to validate the questionnaire results. Winsteps which is based on Rasch model has been used for the data analysis. The item reliability is 1.00, and the person reliability is 0.72. Rasch analysis results indicate that:(1) There were no significant progression with students grades, most of them were at level 4 and below, that means most of them can only accomplish understand and apply tasks based on single-Perspective; (2) The amount of Cognitive Perspective and complexity of Cognitive Perspective is the key variable which restricts the development of students LPs of galvanic cell; (3) Argue and explain resulted more difficult than items related to predict, while systematic and creative thinking were the most difficult key abilities for the students. Our results thus suggested that Cognitive Perspective building, relating and automating were associated with students' Learning Progression of cognitive development and competence performance in galvanic cell. Furthermore, students' argue and explain activities in class were essential for their LPs. Traditional teaching may lack those activities. Implications for teaching and research are discussed.

[28O5I-5] The Development of a Two-tier Test for Grade 5 Students' Conceptual Understanding on Reproduction (*A0221*)

Xinyan Liu*, Enshan Liu+, and Cheng Liu
Beijing Normal University, China Mainland

ABSTRACT Scientific concept is one of the important parts of scientific literacy, the understanding of scientific concept enables students better understand natural world and solve related problems. Elementary science curriculum is the enlightenment education of science for children, which plays a vital role in fostering children's interest to science and promoting children's scientific literacy. Therefore, it is necessary to have a research into conceptual understanding of primary students on specific themes, and then we can have a deeper knowledge on children's conceptual understanding and their concrete misconceptions on a certain theme, which will help teachers' classroom teaching. Basing on the analysis of previous researches, different versions of elementary science textbooks in China mainland and curriculum standards domestic and overseas, a two-tier test on reproduction for Grade 5 students was developed, which aims to detect students' conceptual understanding and their misconceptions. A two-tier test contains several items which are consisted of two parts. The first part of each item is a multiple choice content question having usually four choices, the second part generally contains four possible reasons for the answer given to the first part. Grade 5 students are chosen for that they are in the middle stage of science learning in elementary school, so it would provide information on students' previous science learning and help to improve the following science teaching and learning. The whole development of the two-tier test could be divided into three stages: (1) defining the content framework; (2) obtaining students' misconceptions; and (3) developing the two-tier test. Both the framework and the test were evaluated by experts and science educators for their fitness. The first stage is composed of three concrete steps, they are defining the knowledge to be investigated, determining the scientific concepts involved and developing a concept map on reproduction. These three steps are essential to ensure the quality of the test. The misconceptions collected during the second stage are derived from previous research, students' interview and open-end test items from the field test. The third stage is the developing of the test, during which the test items are designed, screened, modified through discussion with experts, science educators and doctoral students. Furthermore, a field test was done in this stage at a primary school in Beijing to get further information about the test items, including students' misconceptions, and all the information were used for the refining of the test items. When the two-tier test was completed, 400 Grade 5 students were tested in a city of South China, and 397 valid test papers were recycled. The reliability of the two-tier test is 0.756, namely reasonable good reliably, that is the two-tier test is credible. To sum up, we do achieve the goal of the research, which is the two-tier test developed is valid and reliable. Furthermore, we do find some misconceptions extensively hold by those students, for example petals contain the seeds of the plant.

[28O5I-6] Performance Assessment of Scientific Reasoning Competence in Written Tests of High School Physics (*A0565*)

Moyu Zhang* and Ying Luo+
Department of Physics, Beijing Normal University, Beijing, China Mainland

ABSTRACT Scientific reasoning is one of the most important part of scientific thinking promoted in the new Education Standard of high school physics, cultivating students' scientific reasoning competence. As a hot topic in recent years, studies of scientific reasoning always focus on how to improve scientific reasoning by scientific education. While this study is based on physical learning. How to assess students' performance on scientific reasoning competence in physics classes? How well students perform on it? This study is mainly focusing on these two main issues. Scientific thinking contains four elements: "modeling", "scientific reasoning", "scientific argumentation" and "questioning and innovation". On the basis of performance of scientific thinking, we develop a five-level performance on one of the elements of scientific thinking-scientific reasoning. Firstly, based on the general definition on existing research of scientific reasoning, we define the scientific reasoning competence under the background of high school physics curriculum. And then, according to the analysis of scientific reasoning in physics problem, we found three main variables, e.g. "problem situation", "problem genus" (James G. Greeno, 1978) and "knowledge and method" (a Rasch analysis was used to find out the different performance of students' scientific reasoning)to evaluate the status quo of students' scientific reasoning competence on high school physics curriculum. In addition, we define the level hierarchy description of each variables. A further research project is needed to modify our framework and evaluate the performance of scientific reasoning on samples. We design a two-round-experiments

to achieve these two goals. The first round experiment aims at modifying the assessment framework accordingly and further validate its effectiveness. The questions in written test are about core ideas of physics in Chinese high school which contain obvious scientific reasoning process with different difficulties. Rasch model will be taken as the measurement model. And the second round experiment aims at collecting students' performances. Furthermore, a questionnaire will be surveyed to teachers and a portion of students with performance on low level to find out the intrinsic reason of students' scientific reasoning performance. Finally, based on the result of this study, we will discuss on how to improve the scientific reasoning by physical teaching and learning.

<5J> Informal Settings

Chairs: Akihiko Tomita (Wakayama University), Eun Ji Park (Seoul National University)

[28O5J-1] Observations of the Evening Sky: Learning Scientific Views and Skills in Daily Life (*A0090*)

Akihiko Tomita

Faculty of Education, Wakayama University, Japan

ABSTRACT The author has visited nursery schools, kindergartens, and after school cares for nine years to introduce children wonders of evening sky which is related to real life for children and excitement of space age. The activities are in line with the international astronomy education for children, Universe Awareness. The evening sky activity includes observing the color of the evening sky and its changing, spotting the first star, observing the color and twinkling of the stars, and observing the motion of stars. This activity not only intends a simple astronomy education, but also lets the children improve the basic scientific views and skills, and expects educators improve their skills to introduce children sense of scientific wonder in daily life. For example, awareness of more colors in the sky than expected and the color and brightness changing of the evening sky through careful and fun observations with educators is more important and precious experience for children than just knowing the names of the things to improve children's scientific skills. As the sky is common to all people at everywhere as Earthlings look up to the heaven, observing the sky fosters an international notion that we all live in a planet Earth. We do not necessarily need a concrete notion of a big sphere of Earth itself for all of very young children, but we just need a notion that no matter places we live, at a light-polluted city or a foreign city, the same sky is waiting for us, which fosters the respect to the local site, to others, and to foreign countries. The exciting space age activity includes introducing various heavenly bodies and space development which has been conducted under international collaboration. Educators observe children's change in attitude to science. For example, many boys and girls request to have craft activity including making a big astronaut figure, drawing stars and planets, spacecraft, and space station, enjoying reading science picture books, and enjoying using scientific words such as zero gravity and names of planets. The educators also observe improvement of children's scientific skills. For example, some boys and girls become careful observers of rainbow in the sky and rainbow-like light band in the room, and motion of the clouds in the sky.

[28O5J-2] Communicating Concepts of Sustainable Water Consumption through an Interdisciplinary Science Center Exhibition (*A0099*)

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1. Leibniz Institute for Science and Mathematics Education (IPN) at Kiel University, 2. Universität Hamburg, and 3. Mathematikum Science Center Gießen, Germany

ABSTRACT On average each person in Germany daily uses 120 liters of water. However, this value does not sufficiently represent the water consumption caused by our lifestyle in total. To do so one would have to incorporate additional water volumes that evaporate and are used or contaminated during production of the products we use on a daily basis. Taking these hidden volumes of so called "virtual water" into consideration, we reach a daily consumption of about 3900 liters per capita. In our globalized economy the process of consumer good production and therefore of water consumption does not automatically take place in the country of consumption. Statistically, 69 % of a German's water consumption takes place abroad, frequently in countries characterized by water scarcity. Research is lacking (especially from an intercultural perspective) addressing students' conceptions concerning sustainability and sustainable water consumption, as well as their knowledge about the distribution of global water scarcity and global and personal use of water for consumer good production. A paper-pencil questionnaire was administered to 102 students from four school classes in two secondary schools in Germany. Participants were between 12 and 18 years old (51 higher secondary students; 51 lower secondary students). The questionnaire consisted of five items: three open-ended or half open-ended items (Item example: Explain your understanding of the notion "sustainable development"); two forced choice items (Item example: Mark the countries in the world map that suffer to your belief from water scarcity). Open-ended and half-open-ended items were analyzed via Qualitative Content Analysis with the freely available online tool QCAmap (https://www.qcamap.org/). Others were quantified via counting and visualized in a map. In the following exemplary results concerning students' conceptions are given. Answering the open-ended item about their understanding on sustainability most students referred to the ecological dimension (N=29). Answers dealing with the economical (N=8) and social (N=6) dimensions were given less often. Students mentioned most often the sustainability principle of intergenerational justice (N=69). Intragenerational justice was mentioned less often (N=6) and only with regional coherences. 21 students did not answer to the item. Based on the results of this research, an exhibition was developed using the example of virtual water to evaluate new ways of imparting knowledge and opportunities for acting on sustainability. The interdisciplinary exhibition provides factual information, objects and hands-on experiments to explain the generation of the large numbers of virtual water consumption and where they are formed in global and regional coherences. Visitors are invited to investigate and reflect on virtual water and to discover their own small ways to reduce virtual water in their daily lives. The interactive experiments stimulate students of a lower secondary level to realize the complexity of the topic.

[28O5J-3] The Impact of a Short-Term Camp on Students' Awareness and Mental Models towards Marine Environment (*A0060*)

Hsin-Hui Wang*, Hsiang-Ting Chen, Kuay-Keng Yang, Yi-Ting Pan*, Huann-Shyang Lin, and Zuway-R. Hong+
National Sun Yat-sen University, Taiwan

ABSTRACT There have been only a bunch of studies that have addressed on marine environment, and specially focusing on youth group guiding by Self-Determination Theory (SDT; Deci & Ryan, 2000), which emphasizes motivational orientations as causes of behaviors and highlights the role of perceived control over one's actions in goal pursuits. The purpose of this study was to explore how effects of senior high school students involved a short-term marine environment summer camp on improving their awareness and mental models towards marine environment in Taiwan. A total of 57 participants were voluntarily recruited from 9 senior high schools in Kaohsiung city, who attend a 3-day marine environment summer camp, which included 7-hour marine-based lectures, 1-day field trip on visiting the national marine & biology museum, 4-hour beach adventure, 2-hour marine knowledge group competition, and 3-hour hands-on activity that focused on the marine environment pollution. All participants were conducted Awareness towards Marine Environment Scale (ATMES) and Mental Model Drawing Test (MMDT) to measure students' awareness and mental models towards marine environment. Additionally, 4 target students with the lowest scores on either ATMES or MMDT in the pre-test were selected for individual interview at the end of summer camp. Paired t-tests were used to compare the differences of students' ATMES and MMDT from the pre- to post-tests; ANCOVAs were conducted to explore the similarities and differences between active and non-active motivation students' means on the ATMES and MMDT; and the content theme analyses were used to recognize the changes of target students' ATMES and MMDT. It was found that students' posttest mean scores were significantly higher than their pretest on total means and all of the subscales on ATMES and MMDT. Moreover, the active motivation group students' posttest means of ATMES and on the subscales-"Balance in marine ecology" and "Challenges in marine resources" were significantly higher than their counterparts' means. The interview results were consistent with the quantitative findings. Implications of findings for educators as well as suggestions for future research are discussed.

[28O5J-4] Effects of Science Drama Program on Creativity and Character Education for Science Gifted Students (*A0448*)

Junghee Bae*+, Jina Yoon, and Hae-Ae Seo
Pusan National University, Korea

ABSTRACT This research intends to examine the effect of science drama program on creativity and character education for science gifted students. Science gifted students of 451 enrolled at a Science Gifted Education Center affiliated with University from 2014, 2015, and 2016 for three years were selected as research subject and their responses on various survey instruments, play scripts and video tapes of their theater performance were used for data collection. During science drama program, students choose their most favorite scientists for science drama characters, and wrote drama scripts about chosen scientists' life, scientific discovery, contributions to society, and others. Students also expressed themselves and communicated with others and audience during rehearsal and theater performance. It was found that students expressed their positive reflections on science drama program: said that they understood science drama itself and characters of science drama (85.5% students, 386 of 451), that they obtained knowledge of scientists and science concepts through science drama (58.5%) and that they developed close friendship with peer students while participating in science drama (64.5%). More positive responses included that they increased self-confidence (50.7%); that increased collaboration among group members (44.7%); that felt empathy with drama characters (32.2%); increased sincerity (24.3%) and developed leadership (15.1%). On the other hand, students expressed that they felt negative emotions such as pressure, tension (20.4%). In conclusions, students strengthened creativity and character through science drama program in terms of better understanding about scientists' roles in society, social skills among peer students, self-confidence, integrity, leadership and so on. It was recommended that science program integrated with arts may be effective for developing creativity and character.

[28O5J-5] Becoming a Scientifically Literate Person: Three Science Hobbyists' Stories (*A0552*)

Eun Ji Park*+, Chan-Jong Kim, and Seung-Urn Choe
Seoul National University, Korea

ABSTRACT When illuminating upon science education's ultimate purpose of cultivating a scientifically literate person, is such a person actually being fostered? If so, where they are? And how can they enjoy science in their daily life? To answer those questions, this study tried to find out them and figure out what their features are. Especially, this study focused on those who enjoy science as a hobby because they were expected to show the process of becoming a scientifically literate person through their everyday life. Three participants in diverse fields took part in this study: a science book reader and public science lecturer attendee, an online science broadcaster, and an amateur astronomer and telescope builder. Each participant's life story and experience related to science-hobby was gathered through two to three interviews. Each interview was recorded and transcribed. The data was coded based on an emic approach at first and an etic approach later, which then was analyzed and interpreted. To be more specific, the study intended to: 1) investigate the relationship among the experience after arranging participants' experience related to their science-hobby along their biographical flow; 2) figure out the point and the rate of change in the experience's relational tendency and pursing the change in each of their point-of-view and emotion; and 3) show a comprehensive characteristic and meaning of the participation in a science-hobby that arose in the process to becoming a scientifically literate person. According to the results, in one aspect each participant's story carried a meaning-filled example and in another it had some commonalities. First, there was an initial moment of becoming a scientifically literate person and from that moment the science-hobby related experience tended to rapidly increase. In addition, many past experiences, even though the experiences do not seem to be related, worked as attractors to help the participants start their science-hobby through building

various relationships with science-hobby. Secondly, when pursing the change in each participant's point-of-view and emotion on the hidden side of experiences, there was a flow from a concern for how to keep the science-hobby well to an interest in how scientists perform science to a concern for how to share their own scientific knowledge or their scientific life with others. Conclusively, meaningful features of science-hobby in an individual's process to becoming a scientifically literate person are summarized in three ways. First, when the participants searched the answer of the existential question in a science perspective, they acquired insight through time and space by turning their eyes to the outside world. Second, to enjoy science in everyday life the participants overcame obstacles such as difficulty, fear, or pressure of science or math during their schooling; they experienced the process of searching for their own breakthrough or taking a roundabout way to the nature of science. Third, even though the participants wasn't able to perceive that they were doing science through their science-hobby life, they felt the necessity of scientific reasoning and tried thinking rationally from various angles with the evidence about their everyday phenomena.

<5K> Integrated (SSI, EE, ESD)

Chairs: Hisashi Otsuji (Toyo University), Liu K. Ying (National Taiwan Normal University)

[28O5K-1] Education for Disaster Risk Reduction in Japan: What Should We Teach About Radiation? (*A0550*)

Katsuhiko Yamaguchi

Fukushima University, Japan

ABSTRACT When we faced the nuclear accident of Fukushima Dai-ichi nuclear power plant in 2011, we had not had efficient knowledge of scientific radiation to teach for students. Just after the accident, we, the staff of Fukushima University, quickly progressed the investigation of environmental radiation levels for the land of Fukushima prefecture. Then we strongly recognized the importance of the scientific information collected directly through the measurement. For 5 years after the accident, we have struggled to build the radiation education with the school teachers in Fukushima prefecture. The main issue is to make acquire for students the possibility to tell the correct situation on themselves to other people based on scientific knowledge especially through the measurement data. In this presentation, I will introduce such our attempts through the process from just after the accident to today's issue as below. (1) Direct measurement data was useful for people to keep their safety and to avoid from a prejudice just after the accident. (2) Social activity to secure the safety, like the decontamination from radioactive contamination or checking the radiation level in food, can connect the radiation education. (3) Students can know the scientific aspects of radiation through the environmental measurement, e.g. about the radiation intensity dependence of the distance and shielding. (4) Today's issues are finding the way how to decide to return their hometown and how to educate capable people for decommissioning of nuclear reactors through the radiation education.

[28O5K-2] Education for Disaster Risk Reduction in Japan: When the Land is Covered by the Inconvenient (*A0515*)

Hisashi Otsuji

Toyo University, Japan

ABSTRACT Asia is the region where natural disasters have occurred so frequently, and people have been associated with such unwelcome natural environment. The 2011 Tohoku Earthquake (Mw: 9.0, Dead: 15,889, Missing: 2,601) caused the nuclear power plant accident and, as the result, the land was contaminated with radioactive falls in a wide area. Looking back the Japanese history, we have overcome such difficult condition that the land was covered by the inconvenient substances. Our team is developing an educational material which enables learners to notice the relationship between human being and nature, and the characteristics of the radioactive, focusing on a few of following historical events. (1) In 1707, when the Mt. Fuji erupted, the Tokyo area (about 100 km east of the mountain) was covered about 5 [cm] volcanic ash. And the closer villagers, who had lost their agricultural land, turned over the under tillage soil and the covering ash, using only the farm equipment ("Tenchi- gaeshi"). (2) From the 1910s to 1970s, Toyama plain, that is famous as the rice granary, was exposed by cadmium contamination. The chemical was released into rivers by mining companies in the mountains and caused the "Itai-itai disease." This time, using the machinery, people buried contaminated soil deep enough, laid thick soil on them and put the gravel layer between them, to prevent the rice roots from reaching to the lower soil. (3) After the nuclear power plant accident, the wide area was contaminated with radioactive falls in Fukushima. However, we have nothing to handle them except leaving in a container bag. After comparing the cases above, the learners discuss how people have overcome the disastrous situation and may notice the particularity of radioactive substances.

[28O5K-3] Education for Disaster Risk Reduction in Japan: Developing the In-service Teacher Training Program in Fukushima Pref. (*A0359*)

Tatsuya Fujioka[1*+], Hiroki Abe[2], Hisashi Otsuji[3], and Katsuhiko Yamaguchi[4]

1. Shiga University, 2. Tomioka Daiichi Junior High school, 3. Toyo University, and 4. Fukushima University, Japan

ABSTRACT This presentation will introduce the Education for Disaster Risk Reduction in Japan, focusing on "STS" and "ESD" as keywords. It is true that the 2011 off the Pacific coast of Tohoku Earthquake (Mw:9.0, Dead:15,889, Missing:2,601) gave a big shock to Japan, but we have experienced several serious natural disasters. After the 2011 Great East Japan Earthquake, all of local school boards have enhanced the Disaster Prevention in Japan. Especially, in Fukushima Prefecture, where severe damage by not only the Earthquake but also nuclear power plant accident was followed, the Board of Education has planned and conducted several projects for resilience, such as development of the in-service teacher training program of Disaster Education and Radiation Education for all public schools and the distribution of a series of supplementary textbooks and teacher's guides. The authors coordinated the program, gave the lectures at regional meetings and edited the materials, which were aimed to cultivate students' ability for zest for living. Totally, more than 800

leading teachers from all public schools participated in a locally held in-service program, with the use of newly developed materials. The teacher training program covered the following contents: (1) the disaster memorial education, (2) the understanding of the natural environment of Fukushima Prefecture where any kind of natural disaster can occur, such as heavy rain, snow, earthquake, tsunami and volcanic eruption, (3) the blessings of nature and the attachment for the homeland through the awareness of the rich culture and tradition to be praised, (4) the recognition of the nature of STS (Science, Technology and Society), and (5) the integrated initiatives of school and community for safe and secure local place and human development. The implementation rates of radiation and disaster prevention education in public elementary and junior high schools were 100% respectively by 2016. A questionnaire revealed that, depending on our developed materials, each school has prepared an overall disaster prevention plan, which was concerned for the actual condition of the students and community. Today as numerous natural disasters occur not only in Japan, but also around the world and efforts to prevent them have become an urgent problem. Especially, Fukushima Prefecture has entered into the next long-term stage, overcoming the chaotic confusion. Adopting the holistic approach, the school board of Fukushima Prefecture has launched the reform for sustainable society.

[28O5K-4] Chinese Biology Teachers' Ethical Reasoning Patterns on the Applications of Assisted Reproductive Technologies (*A0047*)

Yu Chen* and Winnie Wing Mui So+
The Education University of Hong Kong, Hong Kong

ABSTRACT Increasing emphasis has been placed on the use of socio-scientific issues (SSI) as the contexts for school science education in recent years. In order to implement a more effective SSI-based instruction, it is essential for science teachers themselves to have adequate ethical reasoning skills regarding SSIs. Hence, this study aimed to investigate Chinese high school biology teachers' attitudes towards and ethical reasoning on the bioethical issue of assisted reproductive technology (ART). A survey was conducted with 59 high school biology teachers in Zhejiang province, Mainland China. Among the 59 participants, 20 are male teachers and 39 are female teachers. Nearly 50 % of the participants had a teaching experience of more than 10 years. An open-ended questionnaire was adopted as the main instrument for data collection in this study. The question was modified based on the instrument used in the international-level study of Macer (1994). This question required the participants to firstly make moral judgments on the use of ART in five situations (with sperm donation, with egg donation, include cryopreservation of embryos, involve surrogate mother, and the normal situation) and then provide with proper justifications. The four ethical frameworks (utilitarianism, rights and duties, autonomy and Virtue values) by Reiss (2008) were applied to analyze the patterns of the participants' ethical reasoning on the ART. The findings indicated that the participants were relatively negative on the applications of this biotechnology with involving donated sperms, surrogacy and cryopreservation of embryos. The traditional Chinese ethical perspectives may contribute to such an attitude trend. This study also found that the participants used the utilitarian ethical frameworks more often than the other three frameworks of autonomy, rights and duties, and virtue ethics. The implications of this study are discussed.

[28O5K-5] Examining Civic Ocean Literacy in Taiwan (*A0453*)

K. Y. Liu*, T. K. Yeh, and P. W. Huang
National Taiwan Normal University, Taiwan

ABSTRACT Ocean literacy is the key to link public with understanding of ocean and ocean's influence, applying ocean knowledge to solve problems and issues regarding the ocean and its resources, and to inform and taking actions to public issues. Previous research related to ocean literacy rarely has been investigated. This study attempted to fill this gap by conducting such an inquiry. The identification of "Ocean Literacy" is still an ongoing process over the world. In 2013, National Marine Educators Association has tried to identify ocean literacy as "ocean literacy is an understanding of the ocean's influence on you—and your influence on the ocean". In Taiwan, ocean issues are covered extensively in the subjects of earth science, geography, history, art, and literature, as shown in the Ocean Curriculum Guidelines (Grades 1–12) from 2008. Ocean education researchers in Taiwan highlight the important objective of ocean education is the enhancement of learners' ocean literacy, including, but not exclusive to ocean conceptual understanding, problem-solving ability, attitude toward ocean, and care about the ocean public issues. The current study aimed to explore public ocean literacy in Taiwan. To measure students' ocean literacy in terms of concept understanding, student attitudes toward the ocean, and students' interesting in studying ocean issues, we constructed and developed the Ocean Conception Test (OCT), Attitudes toward Ocean Inventory (AOI), and employed the and the Interesting in Studying Ocean Issues Instrument (ISOI). Totally 324 subjects, random sampling from high school and college (aged from 17-25), participated in this study. The OCT, a 75questions questionnaire, was designed based on the Ocean Curriculum Guidelines which published by the Ministry of Education. The Ocean Curriculum Guidelines follow the purpose of the White Paper on Marine Education Policies (March 13, 2007), with the intent of strengthening and promoting the educational and economic development of human resources within the marine industry, given that Taiwan is an oceanic country. The mean of score was 45.02 (SD =11.03). Three major misconceptions were identified through analysis of incorrect response of the items in OCT: (1) what is the major mechanism causing sea level rise; (2) what is the major mechanism causing storm surge; (3) The reason why Kuroshio is called 'black current'. The mean score of AOI is 3.48 (SD =0.52), shows subjects have a positive attitude toward marine science. With respect to ISOI, the analysis revealed that the top 3 most interested topics of marine issues subjects would like to study were: 'coral reef ecosystem', 'dead zones', and 'ocean resource conservation'. To conclude, this study may be of importance in providing researchers with a better understanding of civics' ocean literacy. It is our hoped that this analysis and discussion will encourage the inclusion and replication of the public understanding of ocean.

[28O5K-6] Environment Related Features of the Curriculum of a Sustainable and Eco-Friendly School in Central Philippines (*A0379*)

Joji Davila Linaugo
La Consolacion College Bacolod, The Philippines

ABSTRACT Educational institutions are powerful catalysts of change influencing their personnel, students and their parents, and the community as a whole. Sustainable and eco-friendly schools may be described as environment-friendly institutions that have initiated and integrated into instruction, research, extension and administration, programs which are environment-related thereby providing accessible and excellent education. The ASEAN Environmental Education Action Plan for 2008-2012 prioritizes the promotion of this program for the establishment and strengthening of sustainable and eco-friendly schools in the Philippines. It is also found in the Roadmap for the Implementation of Republic Act No. 12 (Environmental Awareness and Education Act of 2008) under the National Environmental Education Action Plan (2009-2014). This paper chronicles the journey of La Consolacion College Bacolod in her pursuit to be a sustainable and eco-friendly school focusing on environment-related features of the school curriculum across all levels (basic education, tertiary level, and graduate education) in varying duration. The parameters were: Integration of Environmental Themes into the Curriculum; In-service Environmental Training for Faculty Members; Environmental Support Instructional Materials for Use by Teachers and Students; and Certificate Programs being Offered by the School. Assessors from the Environmental Management Bureau of the Department of Environment and Natural Resources found out those direct-purposeful learning experiences strengthen the enduring understanding of LCCians on the different concepts in different learning areas thus, preparing them to be lifelong learners. Because project-based learning with sustainability may seem like a natural fit, in LCC Bacolod future management accountants do "green audits", future architects engage in green architecture, future restaurateurs plan a purely organic menu. The endeavor fruited into the recognition of the institution as the most sustainable and eco-friendly school in the Western Visayas Region.

<5L> Teaching/Learning (Learners)

Chairs: Jeonghee Nam (Pusan National University), Fenju Lin (National Changhua University of Education)

[28O5L-1] Impact of Students' Assessment Activities on Reflective Thinking in High School Argument-Based Inquiry (*A0215*)

Jeonghee Nam*+ and Seonwoo Lee
Pusan National University, Korea

ABSTRACT This study focused on the use of students' assessment activities to investigate the impact on reflective thinking in Argument-based Inquiry. The participants of the study were 166 10th grade students (six classes). Over one semester students participated in five ABI programs that we developed. The experimental group (84 students) was taught Argument-Based Inquiry with students' self and peer assessment activities. The comparative group (82 students) was taught without the activities. According to the analysis of the reflective writings, the experimental group had a significantly higher mean score than the comparative group in the 3rd and 5th writing. The ratio of students who showed a metacognitive level of reflection with regards to analysis of inquiry process, understanding of learning, and change of thinking increased in both groups but the experimental group's ratio was higher than the comparative group's. The result of analysis of the reflective practice showed that the ratio of the experimental group's students who reached the metacognitive level of reflection in their writing increased while the comparative group's decreased. Therefore, we conclude student assessment activities can create a learning environment that facilitates student participation, increases the students' engagement in the learning process, and the students' assessment activities can be used as a tool to scaffold learning. [Draft]

[28O5L-2] Model-origin Confusion as to Waxing and Waning of the Moon (*A0224*)

Mitsuru Nakajo[1], Hiroaki Kusunose[1], Aya Kunisawa[2], and Ken Kawasaki[3]
1. Kochi University, 2. Hokuryo Junior High School, and 3. Emeritus Professor of Kochi University, Japan

ABSTRACT This study is aimed at resolving students' confusion in learning waxing and waning of the moon, which is the 6th grade content of science in Japan. The confusion arises when students try to arrange their sketches of phases of the moon. The sketches are obtained from observing the model of the system of the sun, the moon and the earth. The model consists of a flashlight and two small balls. The flashlight is likened to the sun, and the two balls are respectively likened to the earth and the moon. The flashlight and the earth-ball are fixed, and the moon-ball revolves around the earth-ball. In order to ensure consistency between the sketches, namely, results from the model and actual observations of the moon, students have to interpret their sketches as if they were at the position of the earth-ball. Unwittingly overlooking the difference in viewpoints, students usually fall into the confusion. The problem this presentation raises can be summarized as a change in viewpoint. It is helpful to describe what is actually observed on the Northern Hemisphere. Suppose that an observer observes the moon in the first half of its age. The sun is on the observer's right, and then the right-hand side of the moon is illuminated. By contrast the sun is on the observer's left in the second half of its age, and then the left-hand side of the moon is illuminated. It is very difficult for students to arrange phases of the moon by means of the model because the actual observer's right-left sense of direction with respect to the sun-flashlight is reversed in the second half of the age of the moon. Worse, very few teachers have pointed out that the interpretation is critically important in understanding waxing and waning the moon going from the first half to the second half of the age of the moon. The interpretation is equivalent to a change in viewpoint: from the viewpoint established outside of the system to the one established on the surface of the earth and vice versa. Therefore, using this model for teaching phases of the moon, teachers need help students to realize that they are not on the surface of the earth-ball. The strategy we adopt is an introduction of intentional confusion into students' ideas about what is students' viewpoint of their observation. This confusion arises as to

how students display their sketches of phases in the second half of the age of the moon. A few students definitely display those sketches in the wrong way: upside down or contrariwise. Adopting this strategy a teacher, one of the present authors, carries out a science class. The teacher introduces all students, whether or not they are in the confusion, to this confusion, and makes all students consider it. As the result, the teacher leads all students to realize that they unwittingly change their viewpoints at the transition from the first half of the age of the moon to the second. [Draft]

[28O5L-3] Network Technology Resources Blended into the Senior High School's Open-guided Inquiry Instruction: In the Case of "Green Energy" Chemistry Course (*A0405*)

Fenju Lin and Erh-Tsung Chin

Graduate Institute of Science Education, National Changhua University of Education, Taiwan

ABSTRACT How teachers teach an emergent course might be one of the most popular issues of contemporary science education. This study is aimed to explore senior high school students' performance of creativity in the context of an emergent chemistry course "green energy" conducted by the network technology resources blended into open–guided inquiry activities (abbreviated as NTBOI). This is a qualitative research study implemented in a 10th grade class of 44 students separated into nine groups. The inquiry activities are designed as "open-guided inquiry" in the Inquiry Instruction Scale (Stear, Goodrum & Huck, 1998). The topics of inquiry contents are modified from Taiwan senior high school's emergent chemistry curriculum, including biomass energy, fuel cell,....., etc, which are defined as "Green Energy". All the inquiry activities are reviewed by the other senior chemistry teachers of the same school, and are conducted in the classroom for thirty two weeks (sixty four hours). The data collection includes student worksheets, the pre-test and post-test of student Science Representations Questionnaire (Danish & Enyedy, 2006), and semi-structured interviews. The data analysis applies the modified "creativity product table" referenced from Basemer and Lin (2002) which includes three major phases– novelty, problem resolving, and sophistication and integration, for examining students' creativity performance. The preliminary research results show that under the NTBOI teaching context, the students' performance of creativity is improved diversely. There is significant growth in the phase of "novelty", while stable growth in "problem resolving" and "sophistication and integration". Therefore, it might imply that the NTBOI instruction could be suitable for the spreading of emergent course, which would be helpful for developing students' performance of creativity.

[28O5L-5] Analysis of High School Students' Interaction in Design-based Learning in Science Class (*A0601*)

Jongman Park*, Young Sook Shim, and Shinho Jang+

Seoul National University of Education, Korea

ABSTRACT The purpose of this study was to investigate characteristics of high school students' interaction in Design-based Science (DBS), which is an inquiry-based form of learning or pedagogy that is based on integration of design process and the design thinking into the science classroom, and what sort of impact the interaction itself has on the task result of course. For this study, there were two research questions: First, what aspects was observed during problem solving stage during students' interaction in Design-based Science class? Second, What types of DBS interaction effects were appeared on the task results? For this study, a DBS program was developed for 20 gifted & talented 10th graders of J senior high school in Seoul, South Korea. The program 'designing habitat for the earth worm' was developed based on cyclic model with five different stages starting with preparation extending to design, production, briefing and feedback. The developed program was implemented in extracurricular activity class to gifted & talented students. Study was conducted by analyzing conversation between students during small group activities and the resulting product. All of the conversations were recorded and analyzed. The interaction analysis kit (Lee et al, 2002) was used for students' interaction analysis among during the science experiment conducted by students, and the result was then combined with resulting production details. 3 researchers participated for the entire analysis process for leading to the final conclusion. Currently, we are in progress to analyze the data. By the time we present our data in EASE in Tokyo, we anticipate to complete the whole data and analysis results to give us the meaningful implication for science education in creativity area.

Oral 6 (28th, 11:30-12:50)

<6A> Learners (Teaching/Learning)

Chair: Kah Heng Chua (Universiti Sains Malaysia)

[28O6A-1] Research on the Relationship Between the Quality of Oral Scientific Argumentation and the Characteristics of Identity Construction of Chinese Middle School Students (*A0032*)

Yang Deng*+ and Hou-Xiong Wang

Institute of Chemistry Education, Central China Normal University, China Mainland

ABSTRACT Evaluating the competence of scientific argumentation of middle school students has become one of the significant topics today in international science education research. Based on the methodology of qualitative research, this study focus on the relationship between the quality of oral scientific argumentation and the characteristics of identity construction of 6 middle school students in grade 12 in China. Firstly, it is given the construction of the oral scientific argumentation tasks in the context of chemistry (on the basis of "A Burning Candle" task in IDeas, Evidence & Argument in Science, Osborne(2004)), and the qualitative methods for data collection and analysis. Secondly, the performances of 3 dyads from grade 12 in oral scientific argumentation have also been analyzed. The results show that although some Chinese students can construct higher quality scientific argumentation (the higher quality scientific argumentation means argumentation consists of the whole structure components of TAP , a logical justification, and the expressions of concepts are correct which embody well rhetorical features of scientific argumentation) independently, most students can not put forward question, rebuttal and criticism to the lower quality scientific argumentation, and they seldom treat themselves as a

reflective thinker. This study implies that when instructing students in oral scientific argumentation, the teacher should help them not only to construct higher quality scientific argumentation, but also to defend their own ideas and criticize others based on their scientific argumentation.

[28O6A-2] Nanoscience Activities: A Tool to Improve the Relevance of Chemistry Lessons to the Upper Secondary School Students' Everyday Living (*A0239*)

Chua Kah Heng* and Mageswary Karpudewan
Universiti Sains Malaysia, Malaysia

ABSTRACT Chemistry is a subject that has close connection with human's daily life. Students are able to relate the content learned during chemistry lessons in school with the application of the principle of technology and science and its impact on the society. Topics that have high relevance to students' real life and related to current societal issues will easily create the interest among them and vice versa. To make the chemistry relevant it has to address students' intentions and narrow the gaps between students' intentions and the pedagogy. Aside from stressing on conceptual understanding and the appreciation of the nature of chemistry, the learning must somehow shows relevance for functionality in daily live such as to the environment, future employment and for future changes and development within the society. Nanoscience is an alternative approach to make chemistry taught in the classrooms to be much more relevant to the everyday leaving of the students. Following this claims, attempt was made to carry out a study to investigate the effect of nanoscience activities on students' perception on the relevance of chemistry education among Form Four students (equivalent to 10th Grade). The students who involved in this study are around age of 16 years old. Quasi experimental design was employed in the study. A total of 163 students involved (83 from control group and 80 from experimental group). Students' perception on the relevance of chemistry education was measured using Relevance of Chemistry Education Questionnaire before and after the treatment. The experimental group students were taught using nanoscience activities. On the contrary, the control group was taught on the same chemistry concepts using more conventional teacher-centered approach. Data collected was analysed using descriptive statistics, Analysis of Covariance (ANCOVA) and Bayesian Test. Result shows that the experimental group students held more positive view about the relevance of chemistry lessons to their daily life than the control group students. The findings are discussed in detail.

[28O6A-4] A Study on the Effect of Practical Work of Science Teaching and Learning in Beijing's High Schools (*A0069*)

Zhang Xiao and Bangping Ding
College of Education, Capital Normal University, China Mainland

ABSTRACT China's science curriculum reforms have always emphasized the value of practical work (PW) in high schools' science classrooms, and recently tried some reform efforts to increase the effect of practical work of science teaching and learning. In this study, our purposes were to explore the effect of practical work of science teaching and learning in Beijing's five high schools. Both quantitative and qualitative data, collected from these five different schools, include interviews, classroom observations, and pre- and post-tests of experimental skills. Overall, analyses of the data show that after half a year of learning, students' experimental skills, compared with the original low development level, were barely increased, not least in the area of the skills of designing experimental plans, analyzing experimental outcomes, controlling experimental variables, recording, explaining and reflecting. The data of the field notes and interviews with students also indicate that the time allotted to experiments was extremely limited. Instead of guiding students to design experimental plans, explain the experimental phenomena and reflect on the experimental outcomes, science teachers spent most of the limited time available teaching and supervising students to complete experiments according to the schedule planned ahead of the lessons. Most students were bored with such instructional strategies. The results of the interviews also suggest that the conceptions of experiments on the part of most teachers involved were quite naïve, because most of them believed that the function of experiments in science instruction was only to verify or prove the conceptual knowledge covered in the textbooks. These preliminary results of the study unfortunately indicate that the effect of practical work of science teaching and learning was not as desired as usually expected in the high schools investigated. In conclusion, it is suggested that further reforms should focus on increasing teachers' attention to practical work and creating more opportunities for students to complete it.

<6B> Teachers (Teacher Education)

Chair: Yin Boyuan (Beijing Normal University)

[28O6B-1] The View on the Teaching Evaluation of Pre-service Teachers (*A0421*)

Hana Jung* and Youngseok Jhun+
Seoul National University of Education, Korea

ABSTRACT It is essential for a professional teacher to have great skills such as teaching and counselling students, performing their business in charge, and improving themselves and so forth. However, the most important skill as a professional teacher is teaching skill. Nobody can do well from the first term. Having some practice teachings, pre-service teachers could progress their teaching skill by class analysis. As a teacher, self-analysis should on going to develop and strengthen their teaching skills. Class analysis is like a mirror that reflects what teachers do and think in class. Teachers will evaluate other teachers or themselves and find some improvement points that would help them change in a better way. In other words, class analysis would influence teachers' progression in teaching. The view of analysis and the direction of improvements may depend on teachers' belief and thinking, these are strongly resistant to change, though. So, from an early period of teacher's career, it is important to have a good belief and standards in class. Thus in this study, we observe how pre-service teachers analyze classes and find improvements. The purpose of this study is to find implications to advance teachers' professionality in teaching. The target of study was 20 teams were consist of 3~4 pre-service teachers. Each team picked up one person who will open his or her science class and be taken a video during 40min. The other members of a team watched the video and evaluated the class in various aspects. We supplied a standard could be useful for

evaluating, but it was not an enforcement. After collecting the evaluation reports, we read and analyzed it and found some factors that pre-service teachers commonly and importantly consider in class analysis. Second, 3 expert teachers in science was cast to see and analyze some presentative videos would be expected to shows the distinctive nature of pre-service teachers. We compared the view of class evaluation between pre-service teachers and expert teachers.

[28O6B-2] Comparison and Development of Science Teacher's Pedagogical Content Knowledge Assessment (*A0456*)

Boyuan Yin* and Lei Wang+

Institute of Chemical Education, Beijing Normal University, China Mainland

ABSTRACT The pedagogical content knowledge (PCK), as an important indicator of teachers' ability, provides valuable reference to training of in-service teachers. In this study, we first organized the components of pedagogical content knowledge. Then, we analyzed current PCK assessments, such as which carried out in Teacher Education and Development Study in Mathematics(TEDS-M), in the aspect of content, performance indicator, evaluation tool, and methods, followed with an intensive comparison. We found that, current PCK assessments usually includes the understanding of curriculum, students, teaching, and evaluation, but lacks some association with teaching practice. We argued that the "value of content in a specific domain" and the "representation of learning process", which significantly affect teaching goals and achievements, should be taken seriously. Therefore, in this study we try to design an assessment framework including the two aspect mentioned above. We used chemistry as an example and designed performance indicators for junior high school teachers. Chemical change and structure of matter was chose as the main content of assessment. In terms of assessment tools, we recommended an integrated use of Likert scale, multiple-choice question and open-ended question, so that to balance the assessment accuracy and assessment time.

[28O6B-3] The Prevalence of Neuromyths among Teachers, Pre-service Teachers, Parents and Students in Taiwan (*A0487*)

Ying-Chun Cho*, Ting-Kuang Yeh, and Chun-Yen Chang+

Graduate Institute of Science Education, National Taiwan Normal University, Taiwan

ABSTRACT Neuroscientific research finding has drawn a lot of attention in educational fields. The progress of neuroscience finding in human memory, creative, attention, motivation, can serve to inform researchers in educational areas in terms of deriving meaningful implications and practice for learning sciences. However, there are many misunderstanding and neuromyths genesis as the communication and translation between the two fields. Previous studies shown that there were indeed many neuromyths in teachers. Nevertheless, there is a limitation of previous study to infer to other countries or culture, and few of studies investigated the potential effects of the existence of these neuromyths. The neuromyths in education could be adverse effects. Therefore, the aim of the study is to investigate the prevalence of neuromyths and potential effects on teachers, pre-service teachers, parents and students in Taiwan. According to the previous studies, we designed and translated fourteen widespread neuromyth statements, and ten true statements about the neuroscience were also presented in the questionnaire. Our results show that more than 90% teachers and pre-service teachers' had several neuromyths, like "Individuals learn better when they receive information in their preferred learning style (for example, visual, auditory or kinaesthetic)" or "We use only part of our brain. There are still many spaces within the brain could be trained and developed." Moreover, there were the same trends of beliefs in the parents and students. Most teachers and pre-service teachers believe their own conceptual of neuroscience could influence or assist their teaching. Teachers, per-service teachers and parents would like to buy the books, toys or teaching materials related to "Right-brain or whole-brain training." Furthermore, more than 50% parents, teachers and students would like to understand their child/students/own learning ability or aptitude by commercialized products even without convince evidence. The belief of neuromyths could influence the educational or learning practices. We concerned that teachers, parents and students can't distinguish the facts and neuromyth may lead to waste too much time or money on pseudoscientific implication. The study of the prevalence and effects of neurmyths could provide a valuable insight on the challenges of interdisciplinary implication and communication between neuroscience and education.

[28O6B-4] Analyzing Mentors' Mentoring Characteristics in Mentoring Conversations for Enhancing Beginning Science Teacher's Teaching Practice (*A0555*)

Sunduk Lee[1], Dongwon Lee[2*+], and Jeonghee Nam[1]

1. Pusan National University and 2. KAIST Global Institute For Talented Education, Korea

ABSTRACT The purpose of this study was to investigate characteristics of the mentoring and interactions by analyzing conversations between mentor and mentee teachers. Four core concepts were developed for this study to reflect the interaction between mentor and mentee teachers and emphasize a collaborative mentoring program. The four elements were: 'Communication', 'Reflection for Mentor', 'Reflection for Mentee', and 'Evaluation'. Each conceptual element was comprised of four categories for 'Teaching Feedback', 'Seminar and Workshop', 'Self-Evaluation', and 'Mentoring group discussions'. Participants of this research consisted of four mentee teachers and four mentor teachers who work in secondary schools. The teaching experience of the beginning teachers, who were the mentee teachers, was under three years, and that of the career teachers, who were the mentors, ranged from eight to twenty-six years. All mentee teachers are in the science education master's program. Two mentor teachers have a Ph.D. and the others are in the doctoral program in science education. Eight teachers who participated in the collaborative mentoring program formed one-to-one groups, and five one-on-one mentoring meetings were conducted. One-to-one groups were maintained during the five mentoring meetings. To identify mentoring characteristics supported by the mentor teachers, mentoring conversation records and transcripts including mentor journals and lesson videos were collected.

The records were also used to analyze the interaction between the mentors and mentees. The major results of this study can be summarized as follows: Mentors support areas that surfaced during mentoring conversations during the collaborative mentoring program varied, and mentoring characteristics differed according to the mentor. Mentoring by experienced teachers did not always facilitate the development of teaching practice in beginning teachers even though the mentoring content was systematically and concretely supported. The types of interactions during the collaborative mentoring program varied according to the mentoring groups. Mentors who encouraged reflective thinking induced a higher level of teaching in their mentees. The results of this study indicate that mentor teachers need a high level of Pedagogical Content Knowledge (PCK) to improve the teaching practice of beginning teachers. However, to induce the development of teaching, interactions between mentor and mentee teachers that result in reflective thinking are essential and mentor teachers have to be capable of offering constructive feedback to their mentees.

<6C> Communication/Engagement
Chair: Masakata Ogawa (Tokyo University of Science)

[28O6C-1] International School Exchange Program Based on Year Cooperative Student Research (*A0027*)

Man-Seog Chun*+ and Allan Goh
Korea Science Academy of KAIST and National Junior College, Korea

ABSTRACT A common format for international program involves students from one school visiting the partner school for a period of one to two weeks. These exchange students will participate in regular school activities and special exploratory classes created for them. The students also have recreational excursions touring the partner city with buddy students. Furthermore, the exchange students have a home stay at their buddy's house to experience a slice of local culture. Room for innovation, though, remains. How do schools maximize the usefulness of these exchanges, in terms of both academic achievement and global education? To answer this question, the Korea Science Academy of KASIT (KSA) in Korea and the National Junior College (NJC) in Singapore have utilized a new approach to exchange program: a year-long international cooperative research program (ICRP). NJC and KSA have conducted the ICRP exchanges for last 3 years. The model has shown promise to provide science gifted students with a much better experience than the tradition school exchange model that employs only observation and one-off cultural experiences. In ICRP, each school prepares its own research topics and then exchanges them with the corresponding school. If any research topics relate to one another, the schools agree to cooperatively study the shared research topic. When setting up the exchange, one team from each schools is formed with one teacher and a maximum of three students. During an exchange to the partner school, students spend the bulk of their time focusing on the joint science research. They later present their collaborative results at end of the exchange visit. Throughout the process, students develop close relationships with one another. They maintain these connections through social media after the exchange by discussing additional problems or solutions. This communication allows the students to further refine their research in preparation for the second exchange visit at the other partner school. Every year three total joint research projects are conducted with roughly 18 students, nine from each school. Reports are submitted after each visit and after the end of each semester.

[28O6C-2] How Do University Students' Critique Farmers' Arguments and Peers' Arguments about Organic Farming? (*A0151*)

Shu-Mey Yu*+1, Jing-Yu Wu[1], Yao-Kuang Chang[1], Chien-Fang Ku[2]
1. Department of Science Education and Application, National Taichung University of Education and 2. Graduate Institute of Science Education, National Changhua University of Education, Taiwan

ABSTRACT Taiwan has gradually been paying more attention on organic farming according to personal health and sustainable environmental concern. However, some farmers were not adopting organic farming. Organic farming became an authentic socio-scientific issue in Taiwan. Organic farmers bring their own produce to specific organic farmers' market interact directly with consumers every Saturday morning in middle Taiwan. This research was interested in how subjects critique argumentation about organic farming after their experiencing interview and interacting with organic farmers. The purpose of this research was to investigate university students critique farmers' arguments and peers' arguments about organic farming according to dialogues from interview organic farmers and three rounds of argumentation with two intervening critique/discussion in a ZUVIO (Mandarin-趣味喔！Means interesting) IRS (Interactive Response System). Subjects were twenty-four volunteer students taking biology course in department of science education and application, college of science, from a national university in middle Taiwan. Life science critique-oriented argumentation social scientific issue "Do you support organic farming?" was developed by researchers. Life science critique-oriented argumentation social scientific issue was posted on ZUVIO IRS. ZUVIO IRS was designed by a group of graduate students from department of electronic engineers in National Taiwan University. Subjects went to organic farmers' market and interviewed organic farmers. They shared interviewed organic farmers' arguments on ZUVIO IRS. Subjects critique arguments of organic farmers and peers when they went through asynchronous critique-oriented argumentation about dialogues from interviewed organic farmers' arguments, and dialogues from asynchronous peer critique-oriented argumentation on ZUVIO IRS. Instruments were open ended critique-oriented argumentation questionnaires and interview tasks which were developed by researchers and validated by biology science educators. Critique-oriented argumentation questionnaires included subjects' position, arguments, critique farmers' arguments, critique peers' arguments and critique self-arguments. Semi-structured interview tasks were conducted for clarify subjects' critique arguments. Critique-oriented argumentation questionnaires and interview tasks were conducted before, in between asynchronous critique-oriented argumentation about dialogues from interview organic farmers, and asynchronous peer critique-oriented argumentation and after critique-oriented argumentation. Qualitative data collected were 2 rounds' asynchronous critique-oriented

argumentations, 3 times' critique-oriented argumentation questionnaires and interviews. Data analyzed were revised from Wu and Tsai (2007) modes of argumentations, Yu and Yore (2013) quality of argumentations. Students' critique farmers' arguments, peers' arguments critique and self-arguments about organic farming were categorized by constant comparison of university students' critique arguments about organic farming according to dialogues from interview organic farmers and three rounds of argumentation with two intervening critique/discussion in a ZUVIO IRS. Inter-rater reliability was 88%. Results showed that university students' critique farmers' arguments and peers' arguments about organic farming through critique-oriented argumentation was categorized into tended to critique arguments in repetition of their own claims and tended to critique arguments in critical evaluation of claims to knowledge. Detailed case examples of university students' critique farmers' arguments and peers' arguments about organic farming will present in this conference. Implications for further research and practice will provide in this conference.

[28O6C-3] Science Communication from Soccer Sport News (*A0580*)

Xuan He, Xiao-ying Chen, Liang-jun Zhou, Tsung-Hui Cheng, and Ping Sheng Chang

Guangzhou Sport University, Dong Hwa University, National Chiao Tung University, China Mainland

ABSTRACT Due to the development of digital technology, science communication provides science learning through the communication media. Although science news and physical education classes have provided the concepts of the aerobic exercise especially blood circulation, our students still have an alternative concept during exercise. We use the cartoon of soccer sports news to facilitate to learning the concepts of the blood circulation during aerobic exercise. We analyzed science communication properties of the cartoon of soccer sports news by 3E (Entertainment, Enjoyment, and Education) model and AEIOU (Awareness, Enjoyment, Interest, Opinion, and Understanding) connotation. 3E Mode and science architecture: Entertainment: Increase audience's interest and acceptance. Means: Sports news science cartoon, popular language of humor. Emotion: To enhance the participants' scientific issues proximity and identity. Means: The field of sports participation and perception of science content in sports news dissemination. Education: To disseminate scientific information provided to the public in order to enhance the knowledge and quality of life. Means: Science Communication curricula, Information and Communication and survey responses. A. Awareness (awareness): familiarity with the new knowledge of science. Through the news media, sports science into the new knowledge of high interest. Such as: heart and circulatory system, aerobic exercise knowledge. E. enjoy (enjoyment): emotional response. Such as: soccer game and news columns as well as scientific appreciation of art camel. I. Interest (interest): science or science communication spontaneous participation. Such as: students to participate in science courses and to participate in soccer and perception cardiopulmonary function. O. opinion (opinion): the formation of the science-related attitudes, reconstruction or consolidation. Previously prepared based on knowledge, by learning science curriculum, re-cognitive science knowledge sports and human circulatory system. U. understanding (understanding): For the scientific content, the scientific process and its understanding of social factors. Such as: to enable students to understand the principle of generating cardiac blood circulation and the aerobic exercise related reactions in the soccer game, better scientific movement. Furthermore, science communication involves the concepts of science, which relies on understanding of the participation of children from all grade. From above all concepts, we propose to ensure the effects of the 3E model in practical sports communication and explore the feedback of AEIOU connotation which is used in physical education. This approved science communication used in sports news can be a symphony combined with sports science and information communication as well as a good choice to spread sports knowledge to audience easily.

[28O6C-4] Further Development of "Science Literacy for All Japanese" Project Including Risk Literacy (*A0568*)

Motonori Hoshi[1]*, Kazuo Kitahara[2+], Eizo Nagasaki[3], Kazuyoshi Chiba[4], Rie Ohashi[5], Yumiko Nara[5], and Mitsuru Kudo[6]

1. Tokyo Institute of Technology, 2. Tokyo University of Science, 3. National Institute of Education Research, 4. Ochanomizu University, 5. Open University of Japan, and 6. Kyoto University, Japan

ABSTRACT In 2005, we started the project "Science for All Japanese" to seek scientific knowledge, capacity and concept to be shared by all for the sustainable democratic society. More than 150 scientists, teachers, engineers, administrators, media staff etc. were involved in the project. In 2008, we published Integrated Report and Panel Reports of seven areas. The experience of 3.11 disaster of big earthquake and subsequent collapse of nuclear power station led us to reconsider the role and contents of science literacy for a safe and sustainable society. The new project of reconsideration of "Science for All Japanese" started in 2012 when Science Communication Center was established in Japan Science Technology Agency and published the final report was published in 2015. The report includes i) reconsideration of the cultural soil of Japan, which puts more emphasis on integration of opinions than diversity of opinions, ii) tentetiveness and uncertainty of scientific knowledge, which lead to sound attitude to problems without unique solutions, and iii) public property of science, which leads to ethics of science.

<6D> Teacher Education (Curriculum/Teaching Materials)

Chair: Koichi Morimoto (Nara University of Education)

[28O6D-1] The Development of Teaching Materials for Infra-Red Thermography (*A0055*)

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ABSTRACT [INTRODUCTION] The image of Infra-Red Thermography has been shown in the science textbook. The image is effective to understand the conduction of heat etc. However the device of it is very expensive and it was difficult to use it as teaching materials. Recently, the price of IR Thermography device is cheaper than the before and it is considered that it can be used as the teaching materials. [METHOD] We have developed the teaching materials for IR

Thermography. The device is "FLIR E4" and it costs ¥ 140,000. The price is almost as same the laptop computer. We took photos for teaching materials as follows. # The concrete surface and grass on sunshine and sunshade in summer. # The fluorescent lamp that is put off after put on for 1 hour. # The sheep, chicken and human. # The frog in autumn and fish. # The TV is turn off after turn of for 1 hour. # The adaptor is connected to the outlet. # The pun is heated for cooking. # The short electric circuit. # The air conditioner and outdoor unit. # The refrigerator and incubator. # The building wall and the cars in summer. [RESULT] We showed these photos to the undergraduate students who are freshman and sophomore in the primary teacher training course in the University. The students wrote down the effectiveness of these photos. They recognized the heat of the concrete in summer, the effect of grass on the sun shade, the conduction of heat, the emission of heat by the refrigerator and incubator, the different body temperature between homeotherm animal and poikilo therm animal and the heat of the device in the image of Infra-Red Thermography that cannot be recognized heat with naked eye. They thank to see the IR Thermography image. They also describe that they want to buy the device and they use it by themselves. [DISCUSSION] It is considered that the image by Infra-Red Thermography is very useful for understanding about heat conduction and biological therm. As possible, we want to let the students use the device of IR Thermography by the students' ideas. Moreover, we already develop the teaching materials for Ultra Violet rays and radiation. We want to relate the teaching materials for UV rays, and radiation. It is expected that students will understand the invisible rays, the electromagnetic through these activities. [Draft]

[28O6D-2] Assessment of the Capacity Building Program for Grade 10 Science Teachers: The K to 12 Perspectives (*A0328*)

Ricky Magbanua Magno

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ABSTRACT The study examined the effectiveness and curricular implications of the Capacity Building Program (CBP), a professional development program for K to 12 Grade 10 science teachers under Enhanced Basic Education Curriculum. The conduct of this study was anchored on the Context, Input, Process and Product (CIPP) evaluation model. The first component, context evaluation was conducted in terms of the demographic characteristics of the participants and their corresponding competency needs relative to the K to 12 science curriculum and the intended goals and objectives of the CBP. The second component, input evaluation was anchored on the following parameters, namely: implementation plans, logistical requirements, selection process and training design for the implementation of the CBP. Focus-group discussions (FGD) were conducted separately with the participants and the service provider to determine the problems and challenges encountered before, during and after implementation of the CBP. The third component, process evaluation considered the implementation of the program. Data for analysis were generated from the responses of the teacher-participants and the service provider in the interview guide. The teacher-participants' satisfaction of the training program was likewise elucidated through their responses in the Daily Session Evaluation Instrument. The process evaluation revealed that the implementation plan was properly implemented in accordance with the identified needs of the participants as well as in line with the program's goals and objectives despite the occurrence of problems or challenges during the implementation of the CBP from the perspectives of the participants and the service provider. The final component, product evaluation, ascertained the extent to which a program achieved its goals. Thematic analysis approach was employed in the treatment of qualitative data. Paired t-test for dependent samples was used in determining changes in the participants' Science Teaching Efficacy Belief and science content knowledge. Descriptive statistics was used to analyze quantitative data obtained from the participants' teaching performance and end of the program assessment. The school heads' responses during interviews generated central themes involving participants' learning from joining the CBP. The participants-respondents of the study were the 34 trained Grade 10 science teachers, their immediate supervisors and their students as well as the service provider who facilitated the CBP. Mixed methods design was employed in the conduct of the study. Quantitative data were analyzed using descriptive and inferential statistics while the qualitative data employed the use of the thematic analysis approach. The research investigated the content knowledge and pedagogical competencies and capabilities of Grade 10 science teachers as implementers of the K to 12 Basic Education Program. The study explored the capabilities of teacher-participants in terms of efficacy belief, increased content knowledge and enhanced competence in teaching and continued professional development.

[28O6D-3] Perspectives of Filipino Teachers on Lesson Study: A Case Study in the Philippines (*A0486*)

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ABSTRACT Lesson study is regarded to promote continuous professional growth among in-service and pre-service teachers in various countries. Participation in the conduct of a lesson study helps teachers develop exemplary lessons in science subjects in particular. Its popularity and effectiveness among teachers have caught the interest of educators in different countries worldwide. Lesson study was introduced in the Philippines through the University of the Philippines National Institute for Science and Mathematics Education Development (UPNISMED) in 2003. It was introduced to the Filipino science teachers with the hope that its practice may help improve learning among the leaners. Since lesson study has only been practiced the Philippines for just a decade, this research explored on the perspectives of Filipino science teachers towards the practice. Specifically, this research described exactly how lesson study contributes to the professional development of Filipino science teachers. In order to help shed light to this question, the researchers administered a survey questionnaire to 67 randomly selected secondary science teachers in Pangasinan Province, Philippines, during the summer period of 2016. The survey questionnaire focused on teachers' perspectives derived from participating in a lesson study. It also included aspects

about the processes of lesson study and how these relate to teaching and learning process in the classroom. The researchers were able to determine the frequency of engagement in lesson study among the science teachers involved in the research. It was also attempted in this research the to clarify the role of lesson study and how it contributed to the professional development of the science teachers. Moreover, using the result of the study, it is also the goal of this research to improve science education and teacher development in the Philippines. This survey conducted gathered basic information on the perspectives of the participants of lesson study and questions that are intended to the teachers who were involved in the implementation of lesson study frequently. Based on the data gathered, the purposes the teachers to participate in in a lesson study include the perception on the value of professional development, widening linkages, and being a good requirement. Other teachers consider it as an essential part of an academic conference, an activity of a research circle and a study group, and a demonstration activity. During the holding of a lesson study the teachers stated that they were able to engaged in actual tasks like investigation and making of teaching materials, making of lesson plans, learning techniques in observing a lesson, acquiring knowledge and trends in science education, learning new scientific knowledge and skills in the natural science, mastering methods to analyze students' thinking process, experiencing management of science laboratory, and understanding of evaluation and new methods of assessment. Majority of the teachers experienced participating lesson study demonstration activities during the past two years. The following perspectives of the teachers were based on the situations that may be useful in their professional development as a teacher who conducts a lesson study. The activities include investigation of teaching materials, prepare a lesson plan, execute an instructional strategy, demonstration of a class, deliver a lesson study, accomplish the goal of lesson study, and decide on the theme of lesson study. Furthermore, they were able to be involved on tasks related to the promotion of student understanding and achievement, provided mentoring sessions with their fellow teachers in the lesson study group, and joined lectures with other teachers outside the lesson study group. In addition, regarding the three major process of lesson study, the researchers were able to derive the following responses from the teachers who were actually involved in the three phases of the conduct of a lesson study. In the preparation phase, the teachers stated that the most important aspects they were commonly involved with were the process of investigation of teaching materials and preparing a lesson plan. During the implementation phase for a one-hour class delivery of the lesson study they responded that they were able to engage on the stages class engagement according to the lesson plan prepared. Finally, in the post-conference, the teachers were able to address the criticisms and comments raised since these are regarded useful for their own professional development. They have a common idea that delivering a lesson study is an effective means to improve once professional development and the opportunity to interact with colleagues in improving the quality of education. The finding of the study would enable educators to understand the specific professional learning and teaching skills and knowledge of Filipino science teachers gained from participating in lesson study. Considering that lesson study is relatively new in the Philippines, the data can help administrators and practitioners assess its effectiveness and share their gained positive experience to other science teachers in other parts of the country.

[28O6D-4] Assessing Effectiveness of a Nanotechnology General Course on Understandings of Nanotechnology Concepts of University Students with Science Majors (*A0163*)

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National Changhua University of Education, Taiwan

ABSTRACT The purpose of this study was to investigate effectiveness of a Nanotechnology General Course on students' understandings of Nanotechnology Concepts of university students with science major. This study adopted a quasi-experimental design. The experimental group, received Nanotechnology General Course, consists of 65 students (48 chemistry major and 17 biology major. The Nanotechnology General Course introduced basic concepts of nano-structure and its features, nano-materials and everyday life applications, such as nano clothes, nano-anticancer drugs etc. The control group, received readings of nanotechnology without taking any course, consists of 25 students (17 chemistry major and 8 biology major). The readings consist of nano-concepts similar to the experimental group students learn. A self-developed two-tier diagnostic test was used to collect data before and after the treatment. The independent-sample t-test and the paired-sample t-test of SPSS 20 were used for data analysis. The results indicated that a significant difference existed on understandings of nanotechnology concepts between the experimental group and the control group ($p<.001$). In addition, for the treatment group, four obvious improved concepts include "surface Plasmon resonance", "the reducing characteristic of the gold nanoparticles", "the characteristic of the magnetic nanoparticles", and "the nanomaterials which can treat cancer." But there are little improvement for the major concept on "the characteristic of the magnetic nanoparticles" and "the unit transform of the nano structure." Suggestions for nanotechnology curriculum and teachings are provided in this study.

<6E> STEM

Chair: Hongshia Zhang (Nanjing University)

[28O6E-1] Relationship between Zhongyong Literacy and Views on NOS of Chinese Primary Science Teachers in China: Based on a National Survey in China (*A0041*)

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ABSTRACT In order to understand the complex relationship between Chinese culture and scientific literacy for improving the pertinence of in-service teacher training, a national survey of primary science teachers in China was conducted in 2013. The survey districts included 21 provinces and autonomous regions: Beijing, Tianjin, Shenzhen, Zhejiang, Sichuan, Chongqing, Fujian, Shandong, Liaoning, Jilin, Heilongjiang, Shaanxi, Henan, Gansu, Inner Mongolia, Yunnan, Guizhou, Jiangsu, Anhui, Jiangxi and Qinghai. The participants were in-service science teachers in primary schools from one or two major cities in each of

the above districts. The valid responses were 2005. With regard to the special Chinese case, the views on the nature of science were differentiated in two types: the classic and the modern ones in the questionnaire design. Zhongyong as the representative of traditional Chinese culture had been involved in the questionnaire, which means both their moderate attitude to deal with interpersonal relationship and their conservative mode of thinking, e.g. do not go to extremes; overall stability, harmony and moderation are pursuing objectives for doing everything. Through Structure Equation Model the statistical technique, it was found that Zhongyong possessed three constructs, i.e. "Consideration", "Tolerance" and "Prioritizing inter-personal relation", which demonstrated divergent affections on the views of science of the participants. The constructs of "Consideration" and "Tolerance" had positive affection while the "Prioritizing inter-personal relation" had negative affection on the classic views of the nature of science. No significant correlation was found between Zhongyong and the modern view. Through cluster analysis, the participants were divided into four groups: the Naïve, the Scientism, the Post-modernism and the Sophisticates. The main conclusion of this research is that although Zhongyong generally does not contradict to scientific literacy, the element of prioritizing personal relation in the culture may bring about negative affection to scientific literacy development of the people.

[28O6E-2] A Glimpse at GreenMech: Use S-P Chart to Evaluate the Students' Performance on STEM Learning Outcome through Hands-on Technology Contest (*A0583*)

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National Taiwan Normal University, Taiwan

ABSTRACT GreenMech is a hands-on technology contest since 2006 that based on chain-reaction contraptions tournament for elementary and high school students. The participants need to assemble the components in the morning and performance in the afternoon without parents and teachers' help. Through the process, the STEM (Science, Technology, Engineering, and Mathematics) could be learned in an informal and interesting ways. To encourage the STEM education, the evaluation in the afternoon is based on the following criteria: application of scientific principles or laws, application of green energy, Creativity of each mechanical action, steadiness, and so on. In this study we focus on the performance of application of scientific principles or laws. The Student-Problem chart analysis (S-P chart) is regarded as a useful tool to explore the relation between assessment criteria and learning outcome. The results includes student caution index (CS), problem caution index (CP), and homogeneity index. These indexes would help us diagnose student learning conditions, learning difficulties and the fitness of the assessment criteria. In the present study, the collected data in 2015 contest, 135 teams and 38 scientific principles or laws were analyzed. The main results indicate that the most scientific principles the participant used is lever, and the most creatively used is infrared. Furthermore, the other results about learning conditions, learning difficulties and the fitness of the assessment criteria would be discussed.

[28O6E-3] High School Interdisciplinary STEM Curriculum about Waste Management (*A0549*)

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ABSTRACT STEM education has recently received much attention in Thailand's education at all levels. However, how STEM education implement in the schools and classrooms level is unclear for most of the teachers. This paper aims to present the process of developing interdisciplinary STEM curriculum in the school by the collaboration between teachers and science educators. The process will help teachers and educators in creating the school-based STEM curriculum that is suitable with their school context. Since, STEM education aims to develop students to be able to investigate the global issues and to develop solutions for real-world problems by integrating content and skills from different disciplines. The process starts from analyzing the school contexts to find out the topic that is related to students' everyday life and their interest. Waste is one of the major issues found in the school and it is a national issue. Therefore, waste management was selected as the topic of the curriculum. Then, teachers in each subject unpacked their learning indicators, and shared with others. The essential question linking all subjects was created which is "how do we manage waste in our school?" Four key questions are constructed to address the essential questions and drive the learning activities. Firstly, what are measures and requirement of waste management? Secondly, what are the advantage and disadvantage of waste? Thirdly, how many types of waste and how much of them are generated in our school? Lastly, how can we reduce waste in our school? Students learned all four key questions via nine different subjects, namely chemistry, biology, social science, technology, social sciences, art, Thai, English, and mathematics for a semester about one lesson plan (1.5 hours) for each subject. At the end of semester, groups of students created the project to propose school waste management plan to reduce the school waste. Students were assessed both subject matter content and skills in each lesson plan and final project.

<6F> Historical/Philosophical/Sociological/Cultural/Gender Issues

Chair: Jinwoong Song (Seoul National University)

[28O6F-1] Goethe's Theory of Colours and Its Implications for Science Teaching (*A0517*)

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Seoul National University, Korea

ABSTRACT The mechanistic program in science and its teaching may be best characterized by its stress on materialistic, reductionistic, and mathematical understanding of nature, in which the nature is postulated as a great machine consisting of some quantitative properties governed by causal mathematical laws. Despite its great success in modern exact science and technology, researches have been noticing the discouraging outcome of the mechanistic program in education and the loss caused by the resultant alienation of human experience from nature. This alienation becomes highly problematic, considering that most national curricula stress

'understanding of the nature' or the 'interest and curiosity towards the natural phenomena' as their primary goals, and that students' sense experience is without doubt a prominent source of achieving them. This study, as a part of our search for the science education which is complementary to such mechanistic tradition, examines and elaborates upon the methodology found in Johann Wolfgang von Goethe's (1749-1832) scientific writing Theory of Colours (1810). By examining historical materials and related studies, our main purposes are to identify the features of the Goethean science in comparison to the mainstream, mechanistic, and Newtonian science, and also to suggest the benefits of introducing this Goethean approach to school science teaching, particularly in the secondary level. In Opticks (1704), Newton proposed and conducted a series of experiments to conclude that color is a mere representation of different refrangibilities of light corpuscles. Goethe, instead of investigating the abstracted light rays and mathematical causality of color phenomena, studied the intrinsic connections presented by sensory experiences themselves, and the wholeness found among them. Meanwhile, our review of Korean secondary textbooks showed that these intrinsic and qualitative aspects of the color phenomena are rarely being noticed in school science, and that the current school curriculum is relying almost exclusively on the Newtonian approach. Based on the analysis, it is argued that the Goethean way of color science, despite its failure in establishing itself as a concrete scientific theory, still has profound educational values: Goethean teaching can help students to (1) discover the non-mathematical but qualitative aspect of nature; (2) understand natural phenomena as a whole; and (3) associate the objective nature with their own subjective experiences. Finally, we maintain that these three benefits can lead to overcoming the shortcomings of the mechanistic explanation, and further contribute to the de-alienation of humans from nature in science teaching.

[28O6F-2] Using Political Theory to Frame Argumentation for Science Education: The Case of Deliberative Democracy (*A0017*)

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1. National Taiwan Normal University, Taiwan, 2. University of Limerick, Ireland, and 3. Bogazici University, Turkey

ABSTRACT This theoretical paper investigates argumentation in science education, particularly in terms of how deliberative democracy is related to argumentation in school science. Argumentation is about justification of knowledge claims with evidence and it has been increasingly significant in the science education research literature in recent years (Driver, Newton & Osborne, 1999; Kelly & Chen, 1999; Zohar & Nemet, 2002). The theoretical underpinnings of argumentation in science education has typically involved perspectives from linguistics, philosophy, communication theory and cognitive psychology (Jimenez-Aleixandre & Erduran, 2007). Perspectives on argumentation from political theory is virtually absent in science education research. In the paper, example political models of deliberative democracy are used to synthesize implications for argumentation in science teaching and learning. We exemplify models of deliberative democracy and explore their implications for argumentation in school science. We focus on three models proposed by Fishkin (2011), Cohen (1997, 1989) and Gutmann and Thompson (2004). These models are widely cited within political theory in articulating democratic deliberation. Given the scarcity in science education research of deliberation models derived from political theory, we envisage the application of these models as holding the potential to open up a new territory of research that can be extended from theoretical investigation to empirical testing in school science. As with the broader scope of deliberative democracy, participants are given voice and time to discuss evidence and propose claims on the basis of evidence. The features described implicitly underscore the importance of peer review, taking alternative arguments seriously and subjecting them to evidential scrutiny. As such, aspects of deliberative democracy are consistent with scientific cultures and thus have relevance and applicability for educational settings. Deliberative democratic models tend to generate ideal conditions of impartiality, rationality and knowledge. Proponents of deliberative democracy such as Fearon also argue that deliberative democracy produces more sympathy with opposing views; more respect for evidence based reasoning rather than opinion; and a greater chance for widely shared consensus, thus promoting social cohesion. Implications of perspectives on deliberative democracy for teaching and learning scientific argumentation include the articulation of (a) instructional approaches to coordinating group work, (b) norms and values of learning environments, and (c) criteria for evaluation of ideas in classroom discussions. Examples of each category are discussed in the paper with reference to classroom conversations. Overall, the paper contributes to the articulation of school science goals of argumentation with societal goals subsumed in deliberative democracy, and open a new territory of research based on political theory for science education.

[28O6F-3] Gender Issues in the 'Making things' (mono zukuri) and the Science (*A0501*)

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Ochanomizu University, Japan

ABSTRACT In the course selection of women in Japan, we think that the proportion of women in the science and mathematics department is not sufficient. We considered it is necessary to invest the experience of elementary school children and the social situation of their parents. Therefore we have conducted a science experiment sessions, 'making things' (mono zukuri) seminar, robots seminar for female students and symposium in Ochanomizu University. We thought, if female students would participate in those seminars, they would become interested in science. We recruited seminar participant from a general schoolchild to the high school student. In particular, we recruited schoolgirls in junior high school students and high school student. The entry of the respective seminars was about 20. In 'making things' seminar, participants made a mini 4 wheel drive model car called "MINI YON-KU" in Japanese, after receiving a lecture about the mechanism of the electric motor or relation between the number of rotations of the motor and gears. In science experiment sessions, participants conducted electric experiment while receiving a lecture. In robots seminar, elementary school children controlled a robot made with Lego. With such an attempt, we thought it is possible to reduce the gender differences

for science. We administered a questionnaire to the participants of each seminar. In the questionnaire, female students expressed the fun in 'making things', experiments and robots. In these special context excitement, female students that participate were able to experience new challenges. Especially, students who participated in the symposium, who graduated from the faculties and departments of the science, learned that it is important in a wide range of fields of society. And they seem to follow motivated science career path. We think that these seminars helped women to become interested in science and technology.

[28O6F-4] A Research to Develop Cultural Product Innovation: As An Example of Taiwan Cultural Lamp Design (*A0429*)

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ABSTRACT This study belongs to one of the cultural product research which creates a cultural lamp design model with guidelines in order to enhance the Taiwan LED industry development. The cultural product and the industry product have some different performances which are product's appearance and use. The research objectives are mainly to solve the long-standing cultural and creative products for a given impression reproduction and promotion led industrial development in Taiwan. The research findings maybe can create innovation and creativity in the cultural product value-added design. The research process contains the lamp designer's interviews and the prototype cultural lamp test. Research methods use Think-Aloud Protocol Analysis and Statistics. The Taiwanese cultural creativity product was investigated through cultural symbols, modeling studies, material studies, color research, combined with creative, and practical complement each other to extend more possibilities of both cultural and design innovation. In addition, the research process and result maybe can develop a new way how to combine the traditional culture into the modern product. The whole process of innovation and research result maybe is helpful for the cultural product design and innovation, which show the characteristics of Taiwanese culture in the world. The consideration of sampling in the Taiwan's LED industry hopes to add the cultural design elements in the Taiwan lamp design in order to be beneficial for its development. Through conduct this research, the result explored the Taiwan cultural differences with the current international trade of goods and the future cultural product design development. The cultural product design model that the external outlook design level is twenty-two percentages, the middle behavior level is thirty-three percentages, and the internal physic level is forty-five percentages. Each level has its pie chart that shows the property of element and guidelines. The cultural product innovation- as an example of Taiwan cultural lamp design maybe supply one solution for designers to develop the cultural creativity design. At last, the research experiences and results maybe supply an efficient method in cultural creative education. [Draft]

<6G> Learners

Chair: Aris Cerbo Larroder (Philippine Science High School Western Visayas)

[28O6G-1] Executive Function of the Brain and Its Influences on Understanding of Physics Concept (*A0143*)

Mohd Nor Syahrir Abdullah*+, Mageswary Karpudewan, and Zalina Ismail

Universiti Sains Malaysia, Malaysia

ABSTRACT Advances in neuroscience studies have brought new insights into the development of cognitive functions. This subsequently led to more studies concerning how students learn. This includes studies on the role of Executive Functions (EF) of the brain and its influence on understanding of science concepts. EF is a term referring to the psychological construct that is composed of multiple interrelated high-level cognitive skills, encompasses the highest levels of human functioning skills such as problem solving, intellect, thought, self-control, and social interaction. EF is widely believed to be a compendium of constructs comprising three cores: inhibition, working memory and set-shifting. These different aspects of executive functions are imperative in learning of different science concepts. For instance, recent finding indicates that working memory and planning are predictive of conceptual understanding of biology concepts while other findings highlighted the role of set-shifting in learning of chemistry concepts. On the contrary learning physics requires higher order cognitive skills such as problem solving. In this context EF's role as higher order cognitive function is inevitable. However, research relating EF and understanding physics concept is lacking. Therefore, this preliminary study is conducted to examine the influence of three main cores of EFs: working memory, inhibition and set shifting on understanding of physics concept. For this purpose, specific tests from the Cambridge Neuropsychological Test Automated Battery (CANTAB) will be used to assess students' working memory, inhibition and set-shifting. Thirty-one pupils in their fourth year of secondary school (aged 15-16) participated. Pearson's correlation analysis will be conducted to look into the influences of the three cores of EF on understanding of physics concept. The details of the findings will be presented.

[28O6G-2] Prospective Science Teachers' Views about How Plants Gain Their Dry Mass and How the Mass Leaves Human Body During Weight Loss (*A0235*)

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Gazi Üniversitesi, Turkey

ABSTRACT The aim of this study was to investigate prospective science teachers' thinking about i) dry mass increase occurring in plants, ii) weight decrease occurring in human beings, and iii) in which ways the body mass leave human body in case of weight loss. During the study we determined prospective science teachers' knowledge and misconceptions about concepts and facts related to the above mentioned situations. In this study, we used content analysis (as a qualitative research method) and utilized the NVivo9 software for analyzing the qualitative data. Sixty three senior prospective science teachers participated in the study in Spring semester 2012 at two large state universities in Turkey. In this study, a two-stage

diagnostic test was used as the data collection instrument. Additionally, semi-structured, audio taped interviews were conducted with five randomly selected participants. The findings indicate that the participants have several misconceptions about process of photosynthesis and cellular respiration, and that they tend to think intuitively, rather than scientifically in their reasoning. The results and their implications are discussed in detail. However, it should be stressed that although the core concepts of photosynthesis and respiration/cellular respiration, are included in Turkish science curricula since middle school grades, the university level students who are expected to teach these concepts when they become teachers still lack an understanding of their essence. In that regard, the current study has served as a litmus paper for biology educators and curriculum developers for diagnosing understandings and showing the way for improvement in teaching and learning photosynthesis and cellular respiration. [Draft]

[28O6G-3] The Flipped Classroom Pedagogy in Chemistry Education: Case Chemical Equilibrium Course (*A0342*)

Ari Myllyviita

Viikki Teacher Training School, University of Helsinki, Finland

ABSTRACT The flipped classroom pedagogy gives an alternative way of teaching and learning if we compare it to the traditional teaching. In the flipped learning students are supposed to study new material outside of class, usually via reading or lecture videos. During the face to face time, normal lesson, time is used more with higher-order tasks, like tasks as before called homework. It is also possible to concentrate more difficult questions and to support individual learning. In chemistry education the flipped classroom pedagogy (FCP) is not yet commonly used, and very little reported. The classroom activities used in chemistry are different if you compare to mathematics, where the FCP is practiced and reported much more. The problem-solving, discussion, debates are the same, but when you have more time during lessons, you can do more experimental works and longer experiments and also analyzing and modeling the phenomena. Research is a case study and includes analysis about different arrangements (layout graphic), students' feedback (questionnaire), test results (concept test) and teacher's own reflection (teacher's blog). The results introduced students' different attitudes towards increase in students' autonomy. The communication between students and teacher were analyzed: was there opportunity to get support and did student get enough support. Students own work flow and engagement was asked. With the FCP we try promote students' autonomy out of classroom and collaborative learning during the lessons. In the FCP the teacher leaves the direct control of the learning to the students and trusts students' ability and desire to learn. Students said, that they watch about 80% of the videos at home. Teachers role is moving to situations, where individual students need more support and guidance. In this case 10/12 said that they got enough support when it was needed, nobody said that it was not possible to get support. Need of scaffolding and collaboration is also supported by different classroom arrangement; student were sitting in groups. This was the case to 8/12, 2/12 said nothing, and 2/12 did not agree. This classroom arrangement was one focus, when research arrangements were planned. In FCP, the teacher can create differentiation in the group of different skill levels of the students. The teacher's support is based on students' own zone of proximal development (ZPD) at the moment. Here the experience of the teacher or teacher's PCK (pedagogical content knowledge) become more and more crucial. This makes the FCP more difficult to put into practice and to get better learning results. Is this FCP method suitable to chemistry education in every cases? When asked students, do you think this would have been worked earlier courses, only 3/12 agreed. In the traditional teaching teachers choose the level of teaching based on conceptions of the average skill level of the group. How it fits to most of the students?

[28O6G-4] Noticed Gaps in the Teaching and Learning of Authentic Science Inquiry Inside the Classroom (*A0508*)

Aris C. Larroder

Philippine Science High School Western Visayas Campus, The Philippines

ABSTRACT Learning inquiry is defined as doing science the way scientists would do science in the laboratory. In science classrooms, however, learning inquiry is an interaction between students and science teachers only. There seems to be a lack of confirmation from the scientists of science practices inside the classroom in doing inquiry. This case study explores what students and scientists notice when they review separately a research paper. There are a total of eight research papers reviewed by two scientists and 24 students. For each set, a total of four papers were assigned to a scientist to review all papers. Three students were assigned to review one paper each. Both scientists and students were made to review similar paper by pointing out what they notice about the research paper. Qualitative content analysis began by listing down what were noticed by both scientists and students. The commonalities and differences of what both students and scientists noticed in a research paper were described and compared. The instances of noticing were counted and categorized either as task-general or task-specific. The episodes of noticing by both students and scientists were further analysed of its content. The noticing were then transcribed, tallied, and coded to either task general or task specific. Preliminary results show the variation in the number, type, and episodes of noticing which can serve as learning and teaching tool in the conduct of inquiry in the classroom. Examples of noticed gaps are also presented. Results reflect the gaps in the teaching and learning of inquiry.

<6H> Mathematics Education

Chair: Haw-Yaw Shy (National Changhua University of Education)

[28O6H-2] Enhancing Mathematics Skills through Science Activities (*A0459*)

Franklin Rapsing Falculan

Harris Memorial College, The Philippines

ABSTRACT Mathematics plays an important role in many Sciences. Improving Mathematics skills may lead to better understanding of Science and some disciplines. Teaching Mathematics to young children may not always be as plain as computation and lecture and discussion type. To promote another way of refining the Mathematics skills of young

children, iHarris Academy was formed. Nine students from preschool to grade 4 level participated on the iHarris Academy program. Part of it was to conduct 8 activities whose main focus is to teach Science while enhancing the Mathematics skills of the students. The following are the activities performed with the mathematics concepts and skills being developed: (1) seeing sound and telephone cup – comparing and making connections, (2) lava effect and volcanic eruption – geometry: shape, (3) mixtures – counting and measuring liquid, (4) constructing anemometer – length, shape, measuring, and counting, (5) making simple circuit – lines and shape, (6) solar eclipse and making sundial – comparing size, directions, telling time, measuring, estimating, and counting, (7) floating eggs – measuring and counting, and (8) balloon powered car – shape, length, comparing, and measuring distance. The students did each activity hands-on with the guide of the teachers. The activities were chosen with the help of all the iHarris Academy teachers. The activities were done during weekdays for three and one-half hours each day. The schedule of the program includes science and math activities, microbiology activities, music activities, and art activities. This program contributed to the strong evidence that some mathematics concepts and skills can be enhanced and taught not only by practicing through pen and paper but also through science activities.

[28O6H-3] Student's Difficulties with Chemical Calculations (*A0334*)

Lennart Kimpel and Elke Sumfleth
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ABSTRACT Theoretical Background: The role of mathematics and quantitative methods in chemistry is getting increasingly important (Atkins, 1998; Witten, 2005). However, university teachers criticize that it raises problems when students are obliged to use mathematical skills in chemistry lessons, whereas chemistry teachers at high schools deplore the deterrent effect of mathematization (Schanze & Parchmann, 2013). Many high school teachers are not willing to calculate in chemistry lessons, although this is needed for chemistry at university level. But according to latest studies, mathematics is a rather popular subject so that the deterrent effect can't be traced back to a disinterest in mathematics (Pant et al., 2013). Students are not able to use calculations learnt in mathematics in new situations and some of them even think that such a transfer is not appropriate (Witten, 2005; Woolnough, 2000). For example, Höner (1996) has shown that embedding arithmetic problems in chemical contexts reduces significantly the probability of solving. Furthermore, there seems to be a lack of qualitative understanding: students scan their questions for keywords and then apply known procedures. In fact, they look for a formula fitting the given values (Goldhausen & Di Fuccia 2014). Research Project: The aim of this cross-sectional study is to identify the preconditions for successfully solving chemical calculations. For this purpose, first year students shall work on different kinds of questions regarding pure mathematics calculations, chemical calculations, formulas and qualitative understanding. Each student worked on all question types. By this means, we want to identify students' difficulties and possible patterns of success. Additionally, accompanying instruments like the self-concept for chemistry, choice of subjects in high school and the high school grade in chemistry have been used. We run the study with 173 undergraduate chemistry students in Germany. Data were collected at the end of the first term, after all students participated in general chemistry classes. Selected results: The results show that the student's mathematical skills are sufficient for the requirements of general chemistry. But the use of these mathematical skills in chemical contexts causes problems. Additionally, some students struggle with dealing with units and others get difficulties regarding formulas: they don't know them or don't know which one is needed. Both, mathematical skills and formula knowledge are predictors for solving chemical calculations, but the strongest predictor by far is the qualitative chemical understanding. We could also see that students with no chemistry courses or with basic courses in high school are not able to catch up with the students that had an advanced course in chemistry in high school. Implications: There are two main implications: First, a more specific education at university is needed to support under-performing students. Only a few students catch up their lags, but those who do, what sets them apart from their fellow students? Second, the students in high school have to be prepared for the requirements of universities. The urgent recommendation must be not to drop chemistry, but to take advanced chemistry courses when there is any interest in studying chemistry at the university level.

[28O6H-4] Re-constructing Middle School Mathematics Teachers' Mathematics Concepts (*A0081*)

Haw-Yaw Shy*+, Chung-Chiang Chou, Chen-Ju Pai, and Mei-Hsien Chen
National Changhua University of Education, Taiwan

ABSTRACT This study follows up on a research series about the mathematical competencies of middle school teachers. Initial results of the study show that experienced teachers may have gaps in understanding of the mathematical concepts that they have been frequently practicing in class. The objective of this study is to evaluate a professional development program that reconstructs the teacher participant's mathematical conceptual knowledge and examines the subsequent effect on his or her instructional techniques. Referencing the key elements of a prior professional development system (Borko, 2004), this program serves as an integration strategy for the professional development of mathematics teachers. The medium of this program is a comprehensive collection of videos of in-class teaching that is taught by an experienced educator at a teacher preparation university. Along with the videos, there is also a collection of professional development booklets for teachers. Each booklet deals with one conceptual unit and contains four categories of questions: reflections on mathematical concepts, reflections on selected viewed videos, revisions to teaching materials, and reflections on his or her teaching. The participants in this study are 150 middle school teachers who have voluntarily enrolled after attending one of the program illustration sessions held across Taiwan. In the design of this study, participants answer the questions asked in the booklet to complete a professional promotion cycle of one conceptual unit in mathematics. In a period of one semester, booklets completed by the participants; interview data, participant teaching videos, and student work, including

notes and assessment materials, are collected. Data analysis is based on the core conceptual framework for studying the effects of professional development on teachers and students (Desimone, 2008). First, the results confirm that most teachers have trouble expressing certain mathematical concepts correctly. This finding suggests that teacher preparation programs in Taiwan are in need of review. Secondly, video from the experienced educator plays a key role in reconstructing teacher mathematical concepts and to raising awareness of the importance of discourse in teaching. Also, participants come out of the program with greater sensitivity to the balance between conceptual development and problem solving. This is a significant change as teachers were predominantly focusing on problem solving in previous teaching. In addition, inspired by the experienced educator's video, participants are more patient when it comes to waiting for students to understand concepts and paying more attention to student thoughts. Furthermore, because of the participants' change of teaching styles and pace, low achievement students become more willing to engage in classroom activities. Finally, it should be noted that while the progress of student assessment scores is slight, the writing quality of the assessments has advanced significantly. Student writing demonstrates a great variety of thought. Most notably, low achievement students demonstrate a positive attitude when trying to solve problems, instead of simply leaving questions blank.

<6I> ICT

Chair: Jiyeon Na (Chuncheon National University of Education)

[28O6I-1] Historical Studies and Modern Reconstructions of Active-Learning Science Education Methods through the Analysis of Students' Notes since Meiji Era of Japan (*A0127*)

Akizo Kobayashi*+ and Fumiko Okiharu

Faculty of Education, Niigata University, Japan

ABSTRACT We are trying to get new insights into the historical problems for unknown real teaching and learning style of science educations through the Analysis of Students' Notes in Meiji Era of Japan. We will show how Japan have cached up with global top level of science education in Meiji Era by deep connections through worldwide educational interchange with European and Americans countries, and how those of Japanese influenced to Asian countries. It is noted that by ours finding of various students' notes on science, such as "Buturi Hikki", i.e. physics notes, etc. written in Meiji Era in various region of Japan, then we can really get historical new insights which are clearly evidenced by the historical analysis of valuable students' Notes, whereas they cannot clarified by usual previous studies mainly limited only on laws and school textbooks in Meiji Era. We are now constructing about 3 thousands data collections of archival materials on science and mathematics educations etc., by searching for those in various archival sites in Hokkaido, Tohoku, Kanto, Chubu, Hokuriku, Kansai, Chugoku and Shikoku (not yet Kyushu) regions. Investigating those characteristic notes collections and digital archives, we are disclosing how science were really taught by using various text books and how experimental tools were developed and how they are really used for science education in Meiji Era. We are studying to clarify the historical roots of Active Learning (AL) methods on science education since Meiji Era in Japan. Furthermore we are investigating that Japanese systems of science education were how developed in these days and how influenced to Asian countries. For examples, many students from Chinese or Korean were learned and brought back various styles' of teaching methods by using superior teaching materials and by effective hands-on-tools those are developed through worldwide interchange of science education, where real teaching situations are evidenced by analyzing typical students' notes on science and mathematics in Meiji Era. As the modern reconstructions of AL methods for historical teaching devices such as Atwood Machine (AM), we present ICT-based AL modules on air-mass measurements by using collisions of big balloons (BB). It is noted that those AL modules are not only some typical visualizing ICT devices for deeper conceptual understanding in physics, but also some modern reconstruction of historically valuable AM, those were not taught so well as suggested from historical studies of students' notes and teaching devices in these days. We will also present some useful modules as, oscillating big balloon pendulum, many times bouncing on floor & free falling BB and oscillations BB attaching to a spring etc. as further developments of those.

[28O6I-2] What Kind of Difficulties Do Pre-service Elementary Teachers Encounter in the Science Class Utilizing Smart Technologies?: Focused on the Development of Technology, Pedagogy, and Content Knowledge (TPACK) (*A0258*)

Jiyeon Na*+ and Byung-Ghi Jang

Chuncheon National University of Education, Korea

ABSTRACT Recently, science education researchers realized the importance of the teacher when introducing and using technology in the science classroom and became interested in the science teachers' technology, pedagogy, and content knowledge (TPACK). In an extension of these previous studies, this study investigated a case of one university training pre-service teachers based on the concept of TPACK. The purpose of this study is to identify pre-service elementary school teachers' difficulties in the science class utilizing smart technologies. The participants were a professor in the department of science education and nine pre-service elementary teachers who had practical training at an elementary school and took classes related to technology, pedagogy, and science knowledge. The data was collected through semi-constructed and in-depth interviews and two lesson observations. The documents such as participants' guidance plans, daily records produced in teaching practice were analyzed. The results of the research are as follows: We found that the pre-service elementary teachers had the various difficulties in the science class utilizing smart technologies. The pre-service teachers had familiar with smart technology as 'digital natives', while they had a hard time teaching students the use of smart technology in science class and developing some ideas adding smart technology to their science classes. They also had trouble preparing the teaching materials and recognizing the necessity for the use of smart technology in science class. In addition, they felt difficulty in integrating their technology knowledge, pedagogy knowledge, and science knowledge.

<6J> Curriculum/Assessment/Policy (Curriculum/Teaching Materials)

Chair: Yu-Ling Lu (National Taipei University of Education)

[28O6J-1] Using Three-Tier Diagnostic Test to Assess Conceptions of Ionisation Energy in Indonesia (*A0153*)

Nadi Suprapto*[+1,4], Jing-Wen Lin[2], Chih-Hsiung Ku[2], Margaretha A. Pasaribu[3], and Kusumawati Dwiningsih[4]

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ABSTRACT This study aimed to investigate the understanding of ionisation energy among high school students (HSSs), pre-service teachers (PSTs), and in-service teachers (ISTs) simultaneously. A total of 326 participants from East Java, Indonesia: 118 HSSs, 165 PSTs, and 43 ISTs who were majoring in chemistry participated in this study and were invited to complete an Ionisation Energy Diagnostic (IEDI) test. IEDI consisted of 12 multiple choice with three-tier items. The first-tier presented the scientific phenomena and it's complemented by reasoning in the second-tier. The third-tier assessed the level of confidence. The results showed four significant common alternative conceptions were identified: octet rule framework, stable fully-filled or half-filled sub-shells, conservation of energy, and relation-based reasoning. In addition, ISTs performed better than HSSs and PSTs on the understanding of ionisation energy. The findings also indicated the part of alternative conceptions about ionisation energy, especially for Group 1A, Group 2A, Period 2, and Period 3 based on the periodic table. However, by using three-tier tests, the percentages of alternative conceptions decreased from two-tier to three-tier scores as well as from one-tier to two-tier scores. This study gives some implications to chemistry teachers, pre-service teachers, university's faculty members, and Indonesian government.

[28O6J-2] Issues and Trends of Environmental Education at Primary Curriculum in Bangladesh (*A0409*)

Uddin Mohammed Rashel* and Kinya Shimizu

Hiroshima University, Japan

ABSTRACT The Government of the People Republic of Bangladesh is committed to promote Education for Sustainable Development (ESD) for achieving Sustainable Development Goals (SDGs). Environmental Education (EE) is the most effective tools for creating scientific attitudes and awareness among mass people. Although EE has a long history in the field of world education but it is comparatively an innovative concern in Bangladesh. Chowdhury, (2014) describes that EE makes people conscious about the environment both scientifically and socially. Primary Education is the foundation of total school system in Bangladesh and it is the most important phase for student to accomplish proper knowledge and attitudes about the emerging global concern like environment. The ultimate purpose of the study is to explore the real situation of EE in primary education sector of Bangladesh both from policy to execution level with careful investigation of national curriculum and textbook contents. Curriculum and textbook has been analyzed to find out the content related to EE considering EE criteria based on different countries curriculum such as Japan, USA, UK, Singapore, Australia and New Zealand. Report from different international conferences has been examined to discover the world trends of EE around the world. Also some articles related to comparison between Bangladesh and other country's curriculum has been investigated to find out the pattern of classroom practices regarding EE. There is no content in grade one and two of Bangladeshi textbook but still there are some co-curricular activities by which student will learn about their surrounding environment. There are integrated contents into "General Science" and "Bangladesh and Global studies" textbook on which emerging environmental issues such as climate change and human adaptation has not received due attention(Chowdhury MAT, 2014). Most emerging point here is that the teaching-learning activities is not well organized because of the unqualified teacher without any prior training who couldn't apply the instruction into the classroom described in the teacher guide (Chowdhury MA, 2011). There are content related to EE in textbook but not systematically arranged nor fulfilling educational objectives. The Curriculum is changing heading towards sustainable development but still there are lack of clear interpretation of EE. Although there are objectives and competencies regarding EE in the national curriculum but most of the teacher of primary education sector didn't know about that due to poor information systems and insufficient quality training programs. Without proper collaboration between policy makers and field level stakeholder this emerging issue will be in obscure and the SDGs will not be accomplished. So, strong collaboration and active participation of primary level teacher in both policy making and curriculum development should be ensured to make the targeted goals achieved.

[28O6J-3] Using Electroencephalography to Explore Students' Attention and Relaxation Levels during Science Test (*A0422*)

Chin-San Lin*[+], Yu-Ling Lu, and Chi-Jui Lien

Department of Science Education, National Taipei University of Education, Taiwan

ABSTRACT Test is an effective method for assessing students' learning. Some study has pointed out the higher classroom concentration, the higher academic achievement (Yang & Chan, 2014). However, how levels of concentration when taking a test affect student's test performance has not been explored in details. In this study, we use Electroencephalography (EEG) to measure 20 junior high school students' brain waves with two types of scientific questions, concept questions and argument question, and to explore their attention and relaxation levels while doing tests in science classes. After data collection, descriptive statistics, Mann-Whitney U test, one-way ANOVA, and Spearman correlation are used for analyzing data. The scale range of attention and relaxation were defined as follow: 0-33 low, 34-66 medium and 67-100 high. The main findings of this study were as follows: 1. While in doing scientific concept questions and argumentation questions, levels of students' attention are medium (M=48.1 and 40.25) and their relaxation are medium too (M=41.05 and 56.05). 2. Students' attention and relaxation levels during science assessment were not significantly different in terms of gender. 3. Students' relaxation levels in answering scientific concept questions (F=5.63, p=0.013) and in answering argumentation questions (F=3.72, p=0.046)

among students of different science achievement (high, medium, low) showed significant difference. The post-hoc analysis showed that students in medium achievement group demonstrating significantly higher relaxation than that of low achievement group, both in answering scientific concept questions (M=2.11>1.14) and argumentation questions (M=2.56>1.71). 4. There were significant positive correlations between students' levels of attention while doing scientific concept questions and doing argumentation questions (r=.571, p=.009). 5. There were significant negative correlations between students' levels of relaxation and their numbers of correct answers while doing argumentation questions (r= -.601, p=.005). This study provides basic information for further exploration of how different formats of assessments affects students' physiological reactions, so that better assessment strategies and counseling techniques could be established for helping students doing better in their science assessments.

<6K> Teaching/Learning
Chair: Yingye Ling (Beijing Normal University)

[28O6K-1] Kids' Programing Class at a Regional Festival-event as a Practical Training Field for the Students in a High-school Teacher Course (*A0252*)

Shin Muroya
Faculty of Comprehensive Management, Matsumoto University, Japan

ABSTRACT Students in a high-school teacher course in Matsumoto University held a one-hour programing class for children (most of them were about 6 to 12 years old) at a regional festival-event named "Matsumoto Monodukuri (skills to make something) fair". The aim of this programing class at the festival was to teach how to make a program for children. But for the students in our university, it belonged to a Project Based Learning (PBL) type project. Students must complete four steps as follows: 1. Make their own teaching plan through the discussion with other students. 2. Manage the class by themselves at the festival and teach how to make a program to children. 3. Reconsider their class based on the replies to a questionnaire from their pupils. 4. Revise their original teaching plan. Usually, a student in a high-school teacher course in Japan does practice-teach each other in the class at the university and become a student teacher in high-school for two or three weeks. Hence, situations in this project were quite unusual for the students. In order to teach something to the pupils, students must use selected simple words. And a much clearer logic was necessary for the explanation of programming for children. Because one-hour class at the regional festival was limited to one-shot, students were required to manage the class to finish the whole educational process during the class. These kinds of practical but hard situations provide the students a fairly precious chance to learn how to plan and manage a teaching class. After the class, students improved their teaching plans by themselves, for example, in the points as follows: 1. Paying more attentions to the response of the pupils, 2. More detailed time allocations are made, 3. Preparing several kinds of points to check the progress of pupils, 4. Making the learning process in smaller steps. In this paper, comparing the teaching plan before and after the class, we investigate how large amounts of things students have learned through the project. This work was supported financially by COC and COC+ programs in Matsumoto University.

[28O6K-2] Oriented to Hand Making and Comprehensive Practice Courses Design and Practice Research: For the Example of "Winemaking Experience Program" (*A0610*)

Ying Hou, KeWen Liu, and Chuan Li
Beijing Normal University, China Mainland

ABSTRACT Since the reform is opening up, the reform of education is in progress all the time. Over the past decade, "quality education" which we mentioned is mostly stressed in order to comprehensively improve the basic quality of all students as the fundamental purpose, and to obtain ability in practice. Education is not only to acquire knowledge, but also to get training and development of the respective ability. To get out of the single way of learning, do more actual operations and practices, make students combine learning and their life. Knowledge is from the society and daily life, and will also be applied back to the social and life. Comprehensive Practice Courses is comprehensive study under the guidance of teachers carried out by the students' self. It is based on the student experience, and is closely contacted with student life and social reality. And it reflect the integrated application of knowledge of learning activities, is one of the required courses in high school. There are 23 credits of 3 years in the Comprehensive Practice Courses. Research Study includes 3 lessons per week. School should ensure that high school students have 270 hours for research study in the three years. Assessment methods of the curriculum mainly adopts the way of the teachers' feedback process of the students' participation, group presentations and lab reports. The article is based on the requirements for students to improve scientific education. It has the purpose of training students' scientific literacy, then puts the hands-on implementation into the class. Make the "Comprehensive Practical Course" as the carrier and make hand making as the primary means, and then get on the design and practice of Comprehensive Practice Courses. Hand making that is "Actual operation" has very important value in Chemistry teaching. Comprehensive Practice Course is one of New Curriculum compulsory state's high school curriculums. It is a course to guide students to discover the problems from their own life and social life, also to carry out a variety of hands-on learning, focusing on the integrated use of knowledge and skills. We will combine " Hand making " and " Comprehensive Practice Course" in our class. We put the practical operation in the class of Practice Course to support the "implement". Enhance the students' knowledge and ability through the actual operations in the class. The comprehensive practical course with hand making is different from ordinary chemistry experiment courses. It does not rigidly adhere to simple chemical experimental operations. It will give priority to industrial practice and put industrial operations in the class. It will make students do practices to have a better understanding of industrial knowledge, and get more associated knowledge. In order to achieve the real purpose of Oriented to Hand making and Comprehensive Practice Courses, We have designed and developed the "Winemaking Experience Course". Based on the life experiences, put the traditional winemaking process microfilm into the class. Then make students have practical hands-on experiences. Integrate chemistry, biology,

physics and other science courses, break disciplinary boundaries, and undertake a comprehensive cognition and learning. Take students into the world of traditional industries and let them to find out more experience from the scientific mysteries of life.

[28O6K-3] The Effect of Peer Critique on Concept Map Revising (*A0464*)

Yingye Ling* and Cheng Liu

Beijing Normal University, China Mainland

ABSTRACT The concept map based on the theory of meaningful learning, is a graphical tool for organizing and representing knowledge which can promote idea-based learning. Revising is an important and necessary part of concept mapping. Peer critique has the following potentials to help developing concept mapping skills and map revising. Critiquing maps has been found to encourage an integrated understanding of knowledge and more time efficient than generating maps. Peer-generated maps might be easier to compare since they use familiar language and build on similar prior knowledge. Besides, the giver and receiver in peer critique can benefit mutually. Peer critique is also one central part of science activities. To explore the effect of peer critique on concept map revising, 42 biology teachers from junior or senior high schools were enrolled in the concept map training held by the researcher. After map generation and self-revision, participants worked in pairs critiquing each other's map. During this session, oral discourse was recorded and merits of the map they found were written down on worksheets. Participants' interaction with the concept mapping program was gathered via the CmapTools Recorder. Revising results were gained by comparing two maps before and after peer critique session. Finally, effectiveness of peer critique was evaluated by comparing what they critiqued to what they revised. We' ve found: participants tend to focus on the expression of linking words, completeness of contents in peer critique, and make reposition and addition of concepts, links in revision; the effectiveness of peer critique varies depending on different aspects they critique on. Further analyses implicate that the ways of critique and the performance of peer map can affect the effectiveness of peer critique on map revising. 1) A detailed discussion and telling the reason why revising can enhance the performance of mapping, compared to an abstract and general assessment. 2) Merits from peer map can be learnt during peer critique, but sometimes, especially the copy without discussion, may introduce some unnecessary concepts or misconception. 3) In addition, common mistakes in dyad's maps are relatively hard to be found, compared to the differences in between. To achieve a better effect of peer critique, we recommend: 1) the trainers to give a full guidance of what to critique and how to critique before the session; 2) students to be grouped heterogeneously to create a better comparison and discussion; 3) additional instruction is needed to stimulate cognition conflicts and help to change misconception in peer critique.

<6L> Curriculum/Teaching Materials

Chair: Po-Hsi Chen (National Taiwan Normal University)

[28O6L-1] Development of the Computerized Test for Assessing the Green Power Literacy (*A0238*)

Po-Hsi Chen*[+], Kuo-Feng Chang, Shao-Zu Su, Jon-Chao Hong, Hsien-Sheng Hsiao, and Yi-Hsuan Hung

National Taiwan Normal University, Taiwan

ABSTRACT The purposes of this research are to develop the computerized green power literacy test and to investigate the reliability and validity of the test. The PISA (the Programme for International Student Assessment) types items were be used to develop the testlet-based items when accessing the green power literacy, both cognitive and affective aspect. The students' proficiency of the green power literacy before and after the green power engineering course was be compared to investigate the validity of the green power literacy test, as well as the outcome of learning. The assessment dimensions include cognitive ability (remembering, understanding and applying) and affective attitude (objectivity, exploring causality, critical thinking and scientific attitude). Four items type, the cluster true–false items, multiple choice items, short answer items and Likert type items are included in the test. Solar energy related testlets are assembled as a test form to conduct the assessment. The examinees are 428 high school students with grade 11, 84 students are form the environmental science experimental courses (ESEC). Multidimensional item response theory was used to estimate students' latent traits and convert it into a scale with mean 100 and standard deviation 15. Result shows that the green power engineering literacy test provides high internal consistency reliability as well as good discrimination validity no matter in cognitive ability or in affective attitude aspects. The ESEC students perform better than the other students. The differences of these two groups are larger in knowledge remembering than in understanding and applying ability. The assessment of other energy types of green energy engineering literacy will be carried out in the future.

[28O6L-2] Effectiveness of Integrating Argumentation-based Instruction into the High School Earth Science Fieldwork on 10th Grade Students' Learning (*A0594*)

Yi-Pei Tang[1+]*, Yi-Wen Hung[3], Ying-Shao Hsu[1] and Horng-Sheng Mii[2]

1. Graduate Institute of Science Education, National Taiwan Normal University, 2. Graduate Institute of Earth Science, National Taiwan Normal University, and 3. The Affiliated Senior High School of National Taiwan Normal University, Taiwan

ABSTRACT Fieldwork is always mentioned as an important means of earth science education. Due to the uniqueness of earth science in terms of enormousness in time and spatial scale, geologists often apply observation to collect data and adopt inference to explain the real natural phenomena. In contrast, students need to collect data, propose ideas and take consideration of possible explanations in the argumentation process, while these activities are all quite similar to the process of scientists constructing knowledge. Argumentation helps comprehend the scientific thinking and the inference process of students. Therefore, the study aims to combine the training of argumentation capacity with field survey to develop arguments field survey which is different from the former ways of doing field surveys in Taiwan. Hence, the study is to help students not only start with static learning of scientific knowledge through the

arguments field survey curriculum, but also apply the scientific knowledge of the actual natural phenomena for causal reasoning. Moreover, the inquiry-based instruction with the student-oriented and teacher-supplemented approach is adopted, namely that the teachers no longer offer field explanation at the site, but apply pre-designed learning sheets for students to observe certain natural phenomena, recording on iPad and then taking the information back to school. The groups will have discussions for all possible explanations and finally implement argumentation to support their ideas. The students will explain and complete the entire survey process. The curriculum is divided into the three phases of discovery, proof and explanation, which are implemented at the Mystic Coast in Jinshan, Taiwan. The course adopts Toulmin Argumentation Pattern (TAP) as an argumentation framework of this curriculum. The case is the national senior high school in Taiwan Taipei City and objects of trial demonstration in the curriculum consists of 10th graders curriculum development. In this study, through self-designed argumentation ability test, fieldwork record table, teaching reflection, analysis of the course learners learn. The curriculum implementation results show that students have demonstrated improvements on the learning performance of argumentation capacity while provided more than terms and explanations for natural phenomena in field survey, but can describe, explain and reason through observation on the geological phenomena. Moreover, the feedbacks from teachers for the curriculum promotion conducted by national teachers' workshop reveal that this curriculum not only helps to teach with substantial benefits but also helps teachers reflect on the process of knowledge structuring.

[28O6L-3] The Enlightenment of International Scientific Education Evaluation based on an International Comparative Study on the Difficulty of Science Textbooks for Junior High Schools (*A0462*)

Zhu Jiahua*, Chen Yuanhao, and Cui Hong+
Central China Normal University, China Mainland

ABSTRACT In the international comparative study of the difficulty of junior middle school science textbooks, it is found that the science education in our country has the following characteristics: The capacity of scientific knowledge in Chinese junior high school is moderate, but according to the data, there is an obvious gap when compared with America, Australia and other countries. As to the dimension of knowledge, factual knowledge is more than the imperative, and the curriculum is lacking in training students' ability of scientific thinking and practice. As to the difficulty of knowledge, the requirements of scientific teaching put more stresses on recognizing and understanding knowledges, which makes the inadequacy of students' ability of understanding, and cognition. Looking at the world, the implementation of science education increasingly develop towards the trend which focus on the learner centered value orientation, educational objectives aimed at scientific literacy, the mainstream curriculum of Integrated science, the teaching methods in the form of multimedia, and the assessment method based on the development of students. According to the International Comparative Study on the Difficulty of Science Textbooks for Junior High Schools , We have made qualitative analysis and Discussion on the PISA, TIMSS, NAEP and other international science education evaluation, and drawing a comparison about the combination of the three major international science education assessment goal, content, evaluation guide and the national junior high school science textbooks. Another finding of this study is that the focus of international science textbooks for junior high schools has converted from scientific knowledge to the learner according to the status quo. Moreover, the aim of textbooks has been converted from mastery of scientific knowledge to development of students' scientific literacy, the teaching values has been converted from the pursuit of identity to seeking diversify, and teaching method has been converted from reflection of disciplinary development to reflection of interdisciplinary progress. [Draft]

Oral 7 (28th, 13:30-14:50)

<7B> Teaching/Learning
Chair: Hiroki Fujii (Okayama University)

[28O7B-1] Utilizing SCAMPER to Enrich Creativity in Green Energy Project Design (*A0144*)

Jon-Chao Hong and Hui-Ting Hsu*+
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ABSTRACT As the old saying goes "Two heads are better than one", what is it the case for Green Energy creative project design using substitute, combine, adapt, modify, put to other uses, eliminate, and rearrange together (the so-called SCAMPER method)? To answer this question, this study invited 15 college students majoring in engineering to participate in a workshop which students can examine SCAMPER in inventions in relation to Green Energy. Accordingly, this study is an attempt to look at creativity in terms of Green Energy in a sample of engineering students in Taiwan. Before the Green Energy creative project design starts, "1/4 association" and "attribute categorization" were first conducted to enrich students' imagination ability in this workshop. 1/4 association is a method for discovering interesting relations between goods in daily life (i.e. for a sedan, a wheel equals to 1/4 all wheels). Attribute categorization is utilized for listing categories that each category is a characteristic of a subject. Example of an attribute categorization: cat, banana, cup, car, and smartphone. In this example, car and smartphone are mechanical goods, whereas cat, banana, and cup are non-mechanical goods. In order to design a Green Energy project, individual and team brainstorming session were both operated for students to develop new ideas through SCAMPER method. Student's creativity was measured using three criteria: (1) Fluency (the quantity of ideas); (2) Flexibility (the quantity of different categories); and (3) Originality (uniqueness of ideas). For data collection, data from 1/4 association and attribute categorization was used for individual creativity, and team creativity data was collected from brainstorming session with respect to Green Energy project design. Additionally, correlation analysis was employed to examine the interrelationships among fluency, flexibility, and originality. The results of this research showed that from an individual perspective, fluency was significantly correlated to flexibility. From a team perspective, flexibility was significantly correlated to

originality. Unexpectedly, individual fluency and originality did not accumulate into team fluency and originality. However, individual flexibility was found to be correlated to team flexibility. This research demonstrated that individual creative ability in using SCAMPER method does not always reveal itself in team performance, implying that sometimes individual brainstorming produces more and better ideas than group brainstorming.

[28O7B-2] An Analysis of the Characteristics of a Whole-class and Small-groups in a Science Classroom: Focusing on the Perspective of Community of Practice (*A0307*)

Joonhyeong Park[1]*, Jiyeon Na[2], Yong Jae Joung[3+], and Jinwoong Song[1]

1. Seoul National University, 2. Chuncheon National University of Education, and 3. Gongju National University of Education, Korea

ABSTRACT A Science classroom usually consists of a whole-class and small-groups, each of which constructs its own community. Through the teaching and learning process in science classroom, activities of these two communities not only work at the same time but also are related to each other. Thus, firstly, we figured out the characteristics of a whole-class and of small-groups as the first step of describing the relationship between two communities. Specifically, based on the perspective of Communities of Practice (CoP), we investigated the characteristics of two communities in terms of the five structural factors of CoP: common interest; responsibility for learning; open participation; mutual relationship; and practice. For analyzing, we observed five classes taught by one subject teacher in an elementary science classroom in Korea. The lessons were about magnetic field and these were audio- and video- recorded. Cameras and voice recorders were set up to capture both whole-class and the small group activities in the class. As a result, the common interest of the whole-class was more focused on cognitive aspect rather than of small-groups, and the practice of a whole-class was led more by teacher. On the other hand, compared to the whole-class, the common interest of small-groups was more focused on activity and fun. The practice of small-groups was different from that of a whole-class and not changed easily by teacher. Through this study, not only finding connections between the structural factors of two communities, but we also could get implications for the organic relationship between two communities based on the results of the video analysis.

[28O7B-3] A Perspective on Use of Folk Tales in Science Education: Exploring Rivers through Story and Science in Elementary School (*A0411*)

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ABSTRACT Through this study, a model was developed for using folk tales in elementary school science lessons on the topic of a natural disaster. Folk tales carry important meanings in order to transmit the indigenous knowledge necessary to various local communities. In addition, in folk tales relating to natural phenomena, people's views of and observations on nature are deeply reflected. Folk tales relating to natural phenomena are based on the fields of biology and earth science (Miyahashi et al., 2004). In space science education, the use of a folk tale was found to promote students' interest in space and greatly motivate students to learn space science (Meyers, 2005). Therefore, using a folk tale about a natural disaster, the new lesson model aims to enhance pupils' attitudes toward coexistence between people and nature and to promote their ability to make appropriate judgments about how to associate with natural phenomena. The content of the lessons is as follows: (1) Reading a folk tale of people who had suffered when a local river flooded; (2) investigative learning about the features of rivers; (3) group discussions about the question: "Is it possible to manage rivers using science and technology?"; and (4) making appropriate judgments about how to associate with rivers, using the folk tale as a clue. The series of lessons was conducted with 34 Japanese pupils in the fifth grade in December 2015. The results of the analysis of a questionnaire administered at the beginning and the end of the series of lessons were as follows: (1) The percentage of positive answers relating to pupils' attitudes toward coexistence between people and nature increased. For example, a female pupil commented that: "I now understood the importance of folk tales that hold age-old wisdom and observations about nature. Therefore, I want to be sensitive to nature without relying on science and technology too much." (2) The percentage of positive answers relating to pupils' interest and motivation to learn about nature also increased. For example, a male pupil commented that: "I feel fear about real rivers because I have studied a river model in science class. However, I am interested in rivers." (3) To concern themselves with nature through a folk tale is effective for developing pupils' ability to make appropriate judgments. In the worksheets, many pupils commented, "I want to feel nature" and "We should not rely too much on science and technology. It is important to observe nature ourselves." The overall finding that emerged from these results is that the use of folk tales in science education has potential not only for advancing learning about the mechanisms and structure of natural objects and phenomena but also for considering how to associate with natural phenomena.

[28O7B-4] Experiencing Meaningful Learning through Portfolio Development in Ecology (*A0112*)

Carmina Villariba-Tolentino

Manuel S. Enverga University Foundation, The Philippines

ABSTRACT In our society today, students need variety of skills and strategies to acquire knowledge, to interpret and communicate their information, and to solve problems and make decisions. In doing all of these, students require a wide range of critical and creative thinking skills and strategies which they can apply to a variety of situations. On the other hand, science teachers expect students to self-regulate and define their own learning goals and evaluate their own achievement. When students can do all these, one can say that they "understand" that particular concept. Or, one can say that meaningful learning has occurred. As a result, educators were able to perceive that a sound portfolio can exhibit a predetermined, systematic, informative, tailored and authentic learning of students (Valenzuela, 2004). It documents the interest, experiences, progressions, and achievements of an individual that enables an evaluator to assess the level of interest of that person (Sewell, 2004). In this study, the researcher used the method of grounded theory to determine the extent

experiencing meaningful learning through portfolio development of 21 preservice teachers in Ecology of Manuel S. Enverga University Foundation which could possibly be applied to other situations, primarily, to science or non-science teachers, students in all-levels, schools and universities that are in need of an alternative educational assessment that can exert constructivist views of learning. Through observations, journal entries, and face-to-face interviews with students, a theory grounded from this study has evolved and concluded that: "experiencing meaningful learning through portfolio development could mean for them as believing and gaining interest to the project and course, generation of portfolio while choosing artifacts that demonstrate skills and exhibits personalities and through careful planning and conceptualizing, gaining values, connecting and transforming themselves after portfolio development." [Draft]

<7C> Learners (Curriculum/Assessment/Policy)
Chair: Ronghui Zhang (Beijing Haidian Teachers Training College)

[28O7C-1] A Study on Secondary School Students' Understanding of Energy in Chemical Reactions: Based on A Learning Progression (*A0361*)

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ABSTRACT This study focused on building a learning progression of energy in chemical education (ECR). Based on the analysis of science history and disciplines knowledge system, international curriculum comparison and interviews with students, a feature model of learning progressions was built. Two progress variables, cognitive objects and cognitive mode, are derived from the model. With these two variables, a sequence of successively increasing sophisticated ways of energy reasoning was discerned as accounting for different levels of ECR learning progressions framework. The EUPA (Energy Understanding Progressions Assessment) was developed as the main instrument to diagnose students' understanding of ECR. Rasch analysis was used to evaluate instrument functioning and validate the learning progression. We utilized this instrument to assess the understanding of N=821 students from three different learning stage, Grade 9, 10, 11-12. Findings provided evidence that students from Grade 9 are able to coherently explain the phenomenon of energy transfer. Students of Grade 10 have developed an understanding of the endothermic and exothermic reactions. For the students in Grades 11-12, they are able to define the system as needed and to explain the energy conservation between system and its surroundings by digesting the enthalpy change of reactions. We discussed the commons and differences between the results of this study and existing research.

[28O7C-2] The Effects of Hands-On Activities on Students' Basic Science Process Skills: A Case Study of a High School in Cambodia (*A0385*)

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ABSTRACT One of the goals of science education for upper secondary schools in Cambodia is to improve science process skills of the students. However, Baseline Survey Report 2009 showed that in Cambodian secondary schools, most of the students were encouraged to memorize the factual knowledge which was not the basis of science learning. On the other hand, science process skills are a crucial facet of science that enable students to develop their critical thinking and problem-solving skills. Moreover, hands-on activities are the strategy that students learn in active ways which they engage in phenomena or objects and manipulated material. Many studies have stated that this teaching method was efficient to promote both content knowledge and science process skills of students, yet there is no study conducted to test their effects, especially in biology classes in Cambodian secondary schools. This study aims to investigate the effects of hands-on activities on basic science process skills of the students at a high school in Cambodia. To achieve this purpose, quasi-experimental design with control and experimental groups was employed. The study was conducted in one of the high schools in Phnom Penh, the capital city of Cambodia. The sample size of the study was 253 of 10th-graders that were selected randomly from 22 classes. All of the participants were divided into two groups, and then assigned them to a control group and an experimental group. Both groups were taught for 6 weeks (12 hours) of six biology topics selecting from a biology textbook for grade 10 such as the structures of fish, the structure of frog, classification of living things, plants, microscope, and plant and animal cells. The control group was taught by their biology teacher using traditional method (teacher-centered), and the experimental group was taught by the researcher using hands-on activities including fish dissection, frog dissection, classification of plants' leaves, classification of monocot and dicot plants, growing mung bean, using microscope, and observing plant cells with microscope. After six weeks, the basic science process skills test was administered to both groups of the students. The result showed that statistically the mean score of the experimental group was significantly higher than the control group, so the researcher concluded that the hands-on activities effected on promoting the BSPS of the students through hands-on biology classes in the high school in Cambodia.

[28O7C-3] Elementary Students' Perception toward Scientific Models (*A0416*)

Show-Run Lee*+ and Yu-Ling Lu
Department of Science Education, National Taipei University of Education, Taiwan

ABSTRACT Modeling has been regarded as one of important scientific skill to understand science and the world around us. However, many elementary students seem to have difficulties in understanding what modeling and models are. To enable us to know what elementary students know about models, this study selected "Energy Saving and Carbon Reduction" as a theme to develop an instrument to identify student's perceptions about scientific models (ISPSM). This ISPSM was then used to explore elementary students' perceptions regarding scientific models. The structure of the ISPSM followed a study made by Lin, et al. (2008) . The framework of ISPSM included six types of models, which including "reality", "symbolic", "iconic", "diagram", "text", and "context", was adopted, which can be used to explore elementary

students' perceptions toward scientific models. After the ISPAM was tested by 198 students and revised to ensured that the ISPAM had adequate validity and reliability, the ISPAM was then used to survey the third-grade and sixth-grade students' perceptions of the categories of model. Eight classes, four in the third-grade and four in the sixth-grade, of 198 students were involved in this study. The resulting data were analyzed by ANOVA, Scheffe test. In addition to above quantitative analyses, a qualitative analysis was done to interview data which were gathered from six students from third-graders and six students from six- graders. The results of this study are: 1. The ISPSM is with adequate expert-validity and test-retest reliability (r = .91). This represented that the ISPSM could be an adequate instrument for examining students' perceptions toward the categories of scientific models. 2. As to students' perceptions toward scientific models, in terms of categories: (1) The quantitative data showed that: a. The perceptions toward scientific model showed no significant difference between third-grade and six-grade students. Their perceptions were mainly "naive realist epistemology" oriented. b. Both third and six graders tend to perceive "reality" as model, which is significant higher than their perceptions of "symbol", "icon", "diagram" and "context" as models. c. Third graders shows significantly stronger tendency toward "icon" and "diagram" than that of "text". d. Sixth graders shows significantly stronger tendency toward "diagram" than that of "symbol" and "text". e. Boys and girls do not show significant difference in their perceptions toward scientific models. (2) The qualitative data showed that: Interview data also support that both third and sixth graders tend to perceive that imitated objects are so called as "model" The above results revealed that students' perceptions are quite remote from what we hope students to perceive what are models. In addition to this, the results of this study might have suggested future curriculum need to put more emphases to help student to know what scientific models are and how to adequately use those.

[28O7C-4] Exploring Students' Performance on the Chemical Practice Investigating Chemical Reaction (*A0457*)

Ronghui Zhang*+ and Lei Wang

Beijing Haidian Teachers Training College, Beijing Normal University, China Mainland

ABSTRACT Cultivating student ability to do scientific practices has been a principal goal of science education. Chemical practices refer to what chemists do, including synthesizing substances, isolating substances, identifying and measuring substances, investigating structures of matter, investigating chemical reaction, investigating properties of matter. However, little study has focused on performance on chemical practices. This study explored students' performance and performance levels on investigating chemical reaction. The research process can be divided into the following parts. First, a method called task analysis was adopted to reveal the nature and structure of the ability to investigate chemical reaction. Task analysis is the mental simulation about process of doing the practice to extract the key points of doing the practices. Moreover, students' responses to paper-pencil test items were analyzed to prove the nature and structure. Second, founded in the perspective of cultivating students' understanding of nature and structure, a hierarchical performance framework of chemical practices including 3 aspects and 9 subcategories was constructed. The framework reflected what students can do after experiencing activities of investigating chemical reaction and served as the initial hypothesis of performance levels. Third, to test and refine performance levels, instruments were developed based on the framework and administrated to a large sample (N=4170) across grades 9,10,11,12. The instruments were paper-pencil tests, and mainly consisted of open-ended items. Fourth, using multi-dimensional partial credit rasch modeling, item parameters (difficulty) and person estimates (abilities) were concurrently calibrated across grade levels with Conquest. Refinement of performance levels were carried out with item difficulties and the Bookmark procedure of setting cutting scores. This research found that procedure, strategy and chemical cognitive pattern consists of the nature and structure of chemical practice. The procedure of investigating chemical reaction includes proposing questions and hypothesis, planning and generating evidence, constructing explanations and conclusions. The strategies of investigating chemical reaction include predicting relations between variables in reactions, choosing observable indicator of variables, identifying relations between variables with the pattern of data and so on. The chemical cognitive pattern is a stabilized and functionalized cognitive state which comes from chemical core ideas and serves as the perspectives to view the substances and chemical transformations. The chemical cognitive pattern of investigating chemical reaction includes cognitive patterns for chemical reactions and relations of variables. Furthermore, this study indicates that the performance framework can serve as the framework to assess students' abilities to do chemical practices. Finally, the results of empirical data indicated that performance levels of doing the practice investigating chemical reaction consist of five levels, which are the integration of the nature and structure and the performance framework. The implications of this study for assessment and instruction on investigating chemical reaction are also discussed. For assessment, the performance framework provides a systematic and hierarchical framework to construct items, and performance levels provide a scale to diagnose students' ability to do the practice investigating chemical reaction. For instruction, in order to promote students' abilities to do the practice investigating chemical reaction, teachers need to engage students in different kinds of activities to do chemical practices including analysis and design related to the performance framework and performance levels, and to make the nature and structure of the practice explicit to help students understand them through the activities.

<7D> Curriculum/Teaching Materials

Chair: King-Dow Su (De Lin Institute of Technology)

[28O7D-2] The Study on Functions and Values of Chemical Mini Kits and Teaching Approaches with the Support of the Kits (*A0454*)

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ABSTRACT In the process of pushing forward the

inquiry-based learning in secondary chemistry classroom in China Mainland, since there are a large number of students and classes, very few labs and lab managers in secondary schools, students seldom do hands-on experiments in learning chemistry. To solve the problem, we developed a series of Chemical Mini Kits for secondary students. A Kit is a small box which includes a set of experiment materials. which contain mini experiment instruments, reagents, nail scissors cut, black and white background paper, disinfecting wipes, disposable gloves, experimental scheme and so on. With the support of the Kits, teachers need not do any preparation for their classes, less chemical is used and pollution is reduced. So that it provides strong support for teachers' inquiry teaching. We complete three different researches based on Chemical Mini Kits, including the study on evaluating the functions and values of the Kits, investigating what kind of roles students play in doing experiments, and investigating the teaching approaches that teachers use in their classes. A questionnaire was designed and 360 high school students were investigated after their using the Kits in chemistry classes. (1) Evaluate the functions and values of Chemical Mini Kits The functions and values are evaluated from three domains: the epistemology functions, process skills and abilities, and affective factors. First, the epistemology functions include four aspects: providing facts for chemical substances and reactions, understanding the principles of chemical reactions, learning safety knowledge, learning experimental operation. Six questions are set from above four aspects. The findings show that the Kits play remarkably function in some aspects, for example 82% students support it can promote observing and understanding chemicals, 79% students support it can help understand the principles of chemical reactions. Second, process skills and abilities include six aspects: orderly operation, asking questions and so on. Eight questions are set from above six aspects. The findings show that 82% students support it can develop their ability of solving problems independently, 79% students support it can develop their ability of orderly operation, etcetera. Third, affective factors include five aspects so that six questions are set. The findings show that 82% students support it can develop their habits of doing experiments dedicatedly and carefully, etcetera. (2) Investigate what kind of roles students play in doing experiments We divided the roles students might play in doing experiments into three types: the core controller, who can raise questions initiative when do experiments; operators and observer, who can do and record the experiments effectively and only observer. The results of the survey show that: in routine chemical experiments, the proportion of the there roles mentioned above are 58.7%, 39.1%, and 2.2%, while they are 72%, 26.9%, and 1.1% respectively in do experiments with using the Kits. For more students play the role of core controller, it means the Kits can make the students engage in the experiments deeply. (3) Investigate the teaching approaches that teachers use in their classes We divided teachers' teaching approaches with the support of the Kits into two types: traditional approach and inquiry-based approach. The survey found that 63.9% teachers adopt the traditional approach, while 29.7% of teachers adopt inquiry-based approach. We also found that few teachers (only 28.4%) explained how to operate the Kits clearly, so that students' activities are less ordered and it takes more time to finish an experiment as we expect. Based on the investigation, we give several suggestions on instruction with the support of Chemical Mini Kits.

[28O7D-3] Vocabulary and Word Study to Increase Comprehension in Science Concepts for Primary Pupils (*A0562*)

Noel S. Ortega* and Digna B. Marquez
Milagrosa Elementary School, The Philippines

ABSTRACT This research was conducted to examine how instructional strategies and providing Grade Four pupils with vocabulary strategies such as the science hunt, crossword science, Science Rubik's Cube (author's own instructional material), graphic organizer, and match and pair will support word knowledge and increase comprehension in science content. From the literature review, direct instruction and vocabulary strategies were suggested to increase comprehension and word knowledge. The research was conducted in a science classroom. Twenty-four pupils were selected from all grade four classes as participants of the study. Through surveys, interviews, observations and paper tests, it was evident that vocabulary strategies positively improved pupils' ability to comprehend and to understand science content. The findings call for teachers to evaluate their instructional practices to provide direct instruction combined with vocabulary strategies. Many opportunities should be provided for pupils to interact with words on a regular basis across a variety of contexts.

<7E> STEM
Chair: Jon-Chao Hong (National Taiwan Normal University)

[28O7E-1] An Exploratory Study on Analyzing SCAMPER Utilization in Creative Design Workshop between Junior High and Elementary School Students (*A0587*)

Jon-Chao Hong*, Hsien-Sheng Hsiao, Po-Hsi Chen, Yi-Hsuan Hung, Chi-Ruei Tsai, and Kai-Hsin Tai
National Taiwan Normal University, Taiwan

ABSTRACT SCAMPER is an acronym for seven thinking techniques includes substitute, combine, adapt, modify, put to other uses, eliminate and reverse. These thinking techniques provide students multiple ways to think about the related factors, knowledges, and to generate new idea. In the present study, we conduct retrospective study. First, the students were asked to brainstorming designing a product. Then SCAMPER is introduced, they were continuing to modify their inventions before they were all familiar with SCAMPER. When the design is done, they have to write down the SCAMPER thinking techniques they had used. The collected data were analyzed to know the differences of using SCAMPER between junior high and elementary school students. The main results show that: 1. "adapt" and "modify" are the most used thinking techniques. 2. The elementary school students used "substitute" more than junior high school students. 3. Both junior high and elementary school students had difficulties used "put to other uses", "eliminate" and "reverse". 4. The students were confused between "adapt" and "modify". 5. There is pattern that "adapt" and "modify" were used to modify the same problems. According to the results, the differences between junior high school students and elementary school students

were discussed.

[28O7E-2] The Difference of the Students' Trait on Skill Learning by Animation Clips (*A0588*)

Jon-Chao Hong* and Chun-Hsin Chang
National Taiwan Normal University, Taiwan

ABSTRACT Animation has been adapted as an efficient learning materials in social media. However, the previous studies put more focus on the learning outcome and affective factors that animation might effect on the cognition development but ignore the skill learning performance. Extraversion is a higher-order personality that featured sociability and expressiveness, while neuroticism characterized anxiety and negative emotionality. Evidences showed that personality might affect individual cognition and symbol processing system. The animation is regarding as metaphorically spatial-visual stimuli in present study, therefore, the individual difference of cognitive failure and cognitive fatigue might affect the learning achievement applying the animation as a learning material. Thus, the present study design an animation of car repairing as a learning material to find out if animation can work as well in skill learning to different trait of students. To reach the aim of this study, neuroticism, extraversion, cognitive failure, cognitive fatigue, and the hands-on making attitude were conducted in the study. A total of 70 vocational high school students participated and completed the questionnaires. In this study, the participants were asked to watch the 5 minutes car repairing clips and repairing the malfunction. Our study indicated that there are some difference existed between high achievers and low achievers. Pedagogical considerations are suggested to conduct animations on skill learning.

[28O7E-3] Relationships among Influences, Academic Engagement, and Achievement of STEM Undergraduates: A Structural Equation Modeling Study (*A0203*)

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1. University at Buffalo, SUNY and 2. Shandong University of Finance and Economics, USA

ABSTRACT The quality of undergraduate STEM education is essential due to the lack of qualified scientists and engineers in the world labor market. This research explores the relationships among student engagement, academic achievement, and other influences in STEM fields by using structural equation modeling (SEM). The variables in the model are synthesized from 7500 pieces of student survey from eight universities in a province in Eastern China. The results illustrate excellent variable constructs by using confirmatory factor analysis (CFA). The full SEM model shows a reasonable fit between the empirical data and the theoretical framework. The direct effects from structural influences (including institution requirement, course requirement, family Social-Economic-Status, and student academic background) to immediate influences (including institution support, teacher support, and student beliefs and attitude) are clearly shown. Furthermore, the immediate influences positively affect student's engagement. Finally, the bidirectional relationship between engagement and achievement is illustrated. The research provides empirical evidences on the relationships among influences, engagement, and achievement of STEM students. In addition, the comparative study of the relationships between 6216 STEM students and 778 non-STEM students is also conducted. The results show significant difference between the two groups of students.

<7F> Historical/Philosophical/Sociological/Cultural/Gender Issues

Chair: Akiko Sato (Ochanomizu University)

[28O7F-1] The Study of Skills-based Senior High School Students' Attitudes, Cognition and Acceptability to Homosexuality (*A0275*)

Chia-Cheng Yeh, Hung-Shun Huang*+, and Ya-Yun Shih
Department of Industrial Education, National Taiwan Normal University, Taiwan

ABSTRACT The skill-based senior high school provides professional subjects and practicum as the core curriculum, which encompasses practical skills. This study investigates the current situation about skills-based senior high school students' attitudes, cognition and acceptability to homosexuality. Researchers take quantitative study as the main research method and take qualitative study for assistance. This study adopts "Homosexuality Attitude Scale", "Homosexuality Cognition Scale", "Homosexuality Acceptability Scale", "Gay Acceptability Scale", "Lesbian Acceptability Scale" and "Open-ended questions to Cognition and Acceptability of Homosexuality" as research instruments to gather information. Utilize purposively sampling to choose158 students (boys: 94; girls: 64) in two skills-based senior high schools in Taipei as objectives. Data obtained in this study was analyzed by descriptive statistics, t-test and the Pearson correlation method. The study results are as follows: 1.There is negative correlation between skills-based senior high school students' attitudes to homosexuality and skills-based senior high school students' acceptability to homosexuality. 2. There is positive correlation between skills-based senior high school students' cognition to homosexuality and skills-based senior high school students' acceptability to homosexuality.3. There is negative correlation between skills-based senior high school students' attitudes to homosexuality and skills-based senior high school students' cognition to homosexuality. 4. There is positive correlation between skills-based senior high school students' acceptability to homosexuality and skills-based senior high school students' acceptability to gay.5. There is positive correlation between skills-based senior high school students' acceptability to homosexuality and skills-based senior high school students' acceptability to lesbian. The outcome offers schools for reference on gender classes.

[28O7F-2] Implementing History and Philosophy of Science on Improving High School Students' Understanding of Nature of Science in Chemistry Teaching (*A0170*)

Qing Zhou*, Shihuan Lu, Xiaocong Yang, and Junping Ma
Shaan Xi Normal University, China Mainland

ABSTRACT This study reveals the effectiveness of implementing history and philosophy of science (HPS) on improving the understanding of nature of science (NOS) of high school students in chemistry teaching. Participants were 94 10th grade high school students who were enrolled into experimental group and control group. Experimental

group students were taught with HPS teaching model, while control group students were taught with traditional teaching approach. The results showed significant differences on understanding of NOS and the scientific world view, but no differences were found on scientific inquiry and scientific enterprise. Gender was an important impact factor on understanding of NOS in chemistry teaching with HPS teaching model which could influence boys' understandings of NOS on scientific word view, but did not work for girls'. Moreover, high-performance students have made great progress on the dimension of scientific inquiry and scientific enterprise, but no significant differences were found on general students and low-performance students, the results also indicated that HPS teaching model could improve students' understanding of NOS positively, especially for those students with high-performance. which means HPS teaching model is an effective teaching method which can improve students' understanding of NOS in chemistry teaching and learning. [Draft]

[28O7F-3] Short-term Overseas Studies on Science for Female Students (*A0513*)

Akiko Sato*[+], Toshiko Amemiya, Katsuhisa Kagami, Noriko Watanabe, Shota Matsuno, and Haruko Ogawa
Ochanomizu University, Japan

ABSTRACT Female university students were sent to universities in the U.S. for short-term study, and female high school students were sent to Taiwan for short-term training visit, and the effects of their visits on their future life plans were analyzed. Seven (7) university students of Group A stayed at University A to study sustainability and related matters for 2 weeks, and 15 university students of Group B stayed at University B to study basics of science and math for 3 weeks. 15 high school students stayed in Taiwan for 4 days and visited hi-tech companies, a hi-tech promotion center, and a high school. The university students were selected from applicants and the high school students were students who took a specific subject. Typical effects of the study visits were as follows: a) Some university students gained self-confidence; One student found her strong point, and others felt they will be able to communicate with English-speaking people and work in English in the future. b) Many university students used the study experience for making future plans, including long-term overseas studies. c) Visiting a high school was included in a program for Group B, which was quite effective for students who plan to become school teachers. d) Group A students studied sustainability from various aspects, which allowed the students to know various scientific fields including economics. e) Many students felt the importance of communication skills and English abilities, which gave them motivation for future studies. f) The high school students were the ones who took a specific subject at school, and they didn't have specific purposes for the study visit. Nevertheless, the visit broadened their view of things. a) and b) above are important especially for female students, because improvement of self-confidence and specific plans are important for female students to decide their future. c) is important for prospective teachers, because global thinking is required for school teachers but teachers usually do not have opportunities to visit schools outside Japan. From these results short-term overseas study is extremely effective especially for female students who face future challenges.

[28O7F-4] Holding and Evaluation "Real Stargazing Party" at an Anime Festa in a Region (*A0291*)

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ABSTRACT Animations, pop songs and other fictional contents are popular among young people in Japan. In such fictional contents, stargazing is often represented hyper-beautifully. Possible socio-cultural background of the phenomenon is that stargazing and astronomy are not familiar in many people's life. Thus, in this research, the author held a stargazing party combined with "TOYAKO Manga Anime Festa" and making people experience in reality stargazing represented in fictions. The party consisted of a night part and a day part. Besides, the author aimed to find out things which participants of the party learned through the party, and relations between the participants' experiences in stargazing, the image of astronomy and the media representation by a questionnaire survey. There were 34 respondents. As a result of the questionnaire survey for participants of the day part of the party, the following was found out: (1) The 65% of respondents was female. (2) The mean age of respondents was 31.0 years old (SD = 12.0). (3) The 17% of respondents answered "Strongly Disagree" or "Disagree" to the question item: "I felt that stargazing became more familiar." They were in the minority. (4) The 64% of respondents had no one around them who liked astronomical observation or stargazing. (5) A variety of media contents having scenes of stargazing or a starry sky left an impression on respondents' mind. These facts indicate the following conclusion: (1) The participants of the stargazing party seemed to feel that stargazing and astronomy became more familiar and to have realized new things. (2)What not yet revealed are details of effects of the stargazing party, and the relation between respondents' experiences in stargazing in the past, their images of astronomy, and media representation.

<7G> Learners (Curriculum/Teaching Materials)

Chair: Hsiang-Hu Liu (National Taiwan Normal University)

[28O7G-1] Problem Solving as Strategy to Overcome Alternating Current Misconceptions of Indonesian Secondary School Students (*A0402*)

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ABSTRACT Alternating current (AC) is one of the most difficult part in physics for secondary school students to understand. In Indonesia, students have to learn the phenomena in AC without any experiments due to lack of or inadequate apparatus. Almost every school has only one conventional oscilloscope; it makes teachers tend to avoid making experiments in science class and to use so-called traditional methods which make students read and listen to the explanation. There is a few subjective class that can improve the knowledge, the skill, and creative thinking of students as well. In addition, most of previous researcher

findings reveal that there are misconceptions, especially about voltage and electric current in simple circuits. To overcome the misconceptions, students must become aware of the scientific conceptions; they must be able to generate the logical relationships among the evidence and alternative conceptions. The misconceptions have a strong connection with problem solving strategy. The problem solving strategy helps students to make a sense of what they are learning by fitting it into what they already knew or believed. They need to be allowed to struggle with a problem to gain confidence in their own abilities, especially in physics. In the lesson, the teacher will provide space for the students to reflect in their own thinking by discussing with a partner or by reporting back to a group or class. Students can deepen their understandings of the processes involved. The aim of this study is to describe student's misconceptions through problem solving strategy. A significant difference can be established if AC is taught by the problem solving strategies as opposed by a conventional learning; and the possibilities of reducing student's misconceptions will be investigated. In this study, students will use a laptop computer which has an oscilloscope software and interfaces as AC measurement equipment as well as multi-meters. We have developed an interface for the measurement of AC circuits properties such as oscillating current, voltage and phase differences. The findings from previous study that student's misconceptions of AC concepts related to voltage, current, power source, the effect of the function of a component at the particular point in time, as well as the characteristics of AC waveforms were elaborated to design the instruments as the two tier multiple choice for pretest and posttest. As Pre-Experimental Research, there are three schools and the total of groups that will be used is six. The first three-group (control group) shall be taught through a conventional learning method and the second three-group (experimental group) shall be taught through the problem solving method. It expected that the findings from this study can overcome student's misconceptions and shall provide better and alternative ways of teaching the AC circuits which shall promote teacher's enthusiasm to teach this topic with confidence thereby dealing with misconceptions.

[28O7G-2] Learning from News Media: A New Teaching Method based on Science News Production Role Playing to Develop Students Oral Report Skills in Junior High School (*A0469*)

Hsiang-Hu Liu

Graduate Institute of Science Education, National Taiwan Normal University, Taiwan

ABSTRACT "Discovery science topics" and "the source and evident" of news were two important elements when reporters creating a science News. To achieve effective dissemination, reporters used good searching skill for seeking useful information when they discovered a new science topic. "News directed" modified and simplified these information into anchor script. Public can understand the easily through News anchors clear oral report skill. This study aims to create a new teaching method based on made student played three major roles in science News production to train students oral report skills. In school, students had not enough chances to practice their oral report ability. This study used action research, interviews and ADIEU scale to investigate students oral report skills development. The target students consist of 38 eighth-graders and 36 seventh-graders picked from a junior high school in the northern part of Taiwan. These participants divided into eight groups, after taking two-month course and performed the report in last class. Preliminary interviews result shows that students cannot express their thinking clearly by oral report before this class. By role playing student can realize the oral report creating step. The research is still ongoing, detailed results will be added in subsequent complete report. [Draft]

[28O7G-3] An Analysis of the Features of the 5-Year-Old Young Child's Exploration Extracted from their "Words" "Facial Expressions" and "Behavior" during the Air Activity (*A0548*)

Takuya Kotani*[+], Yoshiko Nagase[+], and Akira Aratani[+]

Osaka Ohtani University, Japan

ABSTRACT Instead of the subject of science for the 1st and 2nd Grade in primary school, the subject of "Life environmental studies" has been established in 1989. The purpose of this new subject is to find something thorough experience in child's everyday life and utilize their discoveries for solving various problems in their life. Recent statements from the Central Council for Education in the Ministry of Education says that the activities of life environmental studies should be improved to enhance the ability of scientific thought and to connect the curriculum in elementary school with in kindergarten. But now in Japan, we have a few such scientific activities in both the curriculum in primary school and the one in kindergarten. Therefore we should clarify the featuring of early child's explorations to make scientific activities for young children in elementary school and kindergarten. The purpose of this study is (1) to propose our Air Activity for 5-year-old as scientific experience linking to life environmental studies and (2) to extract the features of the 5-year-old young child's exploration from their words, facial expressions and behavior during looking for air bubbles. The aim of our activity is to make their own ideas through scientific experience by using science process skills such as Observation, Communication and so on. In our activity fifteen materials were given each young child. Each 8 sorts of materials such as a plastic ball, a sponge, a fragment of cardboard, a chalk, a green pepper which has a hole, a loaf of French bread, a piece of pumice and a piece of loofah sponge has air inside it. Each 7 sorts of materials such as a marble, an eraser, a piece of pasteboard, a crayon, a cucumber, a rice cake and a plate of granite has no air inside it. Young children can try to explore what type of materials have air inside on their own pace. This activity has 4 parts and total time of it was about 30 minutes. This time a researcher guided young children into this activity. 4 young children aged 5 who are very interested in plants, animals, materials and natural phenomenon were chosen as a subject by their homeroom teacher. Their words, facial expressions and behavior were recorded for about ten minutes by using four digital video camera at a public kindergarten, in Osaka, Japan. Then digital data were converted into some documents. The features of 4 young children's exploration during the activity were extracted from them. The main results of this study are as follows; (1) The total time to explore materials which has air inside it for 4 young children is longer than two times or more that

to explore materials which has no air. This result probably indicates that four 5-year-old children were very curious about air bubbles and needed much time till they understood what materials have air with confidence through many times of trials. (2)The main ways of 4 young child's exploration to find out bubbles are the behaviors such as a "hold", a "squeeze", "crush", a "fold", "shake in water", "changing directions of putting materials into water", a "push". This result probably means that 4 young children got many ways of exploration through everyday life experiences to find out bubbles before learning school science. It is likely that using these exploratory ways in scientific activities like the Air Activity enhance the ability of exploration.

[28O7G-4] Beginning Science Concepts of Filipino Children (*A0561*)

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ABSTRACT This study explored the meanings Filipino children entering grade I have for science words commonly found in grade I science textbooks. Patterns in the meanings children give to these words which differentiate (a) children from rural and urban communities, (b) with or without preschool education (c) male and female, and (d) children whose parents went through different levels of education were investigated. One hundred 6 to 7 year old children from rural and urban sites in the 3 major islands in the Philippines were interviewed regarding 48 science words found in grade I textbooks. They were also asked to draw to explain their ideas more clearly. Chi square tests for each question for each word and ANOVA tests for the whole sample were to find patterns of conceptions considering the variables in the study. In general, the children showed beginnings of awareness, especially in words related to their direct experiences. Although most children could not give a precise definition of terms, they can give explanations, examples and draw about concepts. Differences in the ability to give examples were found among (a) boys and girls, (b) among children who have attended preschool and those who have not, and (c) those whose parents have gone through different levels of education. But all children expressed themselves in drawings. Children's drawings were found to express more understanding about certain concepts which they cannot explain in words. Knowing what children think, either in spoken or graphic responses, gives the teacher an important clue as to where to start and how to start a topic presentation. Children of this age understand science concepts in different ways. Teachers should use children's experiences as a base to build appropriate activities that lead to more accurate scientific explanations.

<7H> Mathematics Education

Chair: Tsu-Nan Lee (The University of Melbourne)

[28O7H-1] The Evidence of Validity and Reliability in Developing an Analytic Scoring Rubric of Geometric Argumentation at Primary Level (*A0013*)

Tsu-Nan Lee
The University of Melbourne, Australia

ABSTRACT Mathematical argumentation is an advanced thinking that is used to help students employ mathematical properties to explain their ideas (Horng, 2004). Students' ideas can reflect their understanding and allow teachers to understand whether the students have misconceptions or not (Vanderhye & Zmijewski Demers, December 2007/January 2008). Therefore, Lin (2013) suggests that teachers should be encouraged to use argumentation in classroom settings when teaching mathematics. It shows that argumentation is important to learn mathematics for students, but there are many scoring rubrics which emphasize on mathematical argumentation at secondary level (Healy & Hoyles, 1999; Lin & Cheng, 2003, December) and neglect at primary level. If mathematics educators expect primary teachers to use argumentation in teaching mathematics, but teachers have no assessment tool to evaluate primary students' argumentation, it will be difficult to use argumentation in teaching for these teachers. From the perspective of teaching, this study aims at developing an analytic scoring rubric (ASR) to evaluate primary students' mathematical argumentation. The Trends in International Mathematics and Science Study (TIMSS) indicates that although Taiwanese grade 4 students rank as top five in the world, students did not perform well in geometry and reasoning in comparison with other mathematical competences (Mullis, Martin, Foy, & Arora, 2012). Geometry is a subject which discusses the relationship between different shapes and reasoning is the core competence in learning geometry (National Council of Teachers of Mathematics [NCTM], 2000) Students in argumentation have to use reasoning to explain their ideas. Australian Curriculum Assessment and Reporting Authority [ACARA] (2010) points out that students should learn geometry through argumentation. Therefore, this study adopts a sorting task of classifying triangle shapes for the main task and there are 168 Taiwanese grade 5 students from 8 primary schools in different cities to participate. Geometric argumentation in this study refers to a discourse that students are able to employ correct geometric properties to explain relationships between a target shape and a chosen one via reasoning (Lee, 2015). This study extends Lee's (2015) previous work and confirms his hypotheses: Lee (2015) analyses the definition of geometric argumentation and assumes that there are three indicators in ASR to evaluate primary students' geometric argumentation, including naming, supporting ideas and transformation reasoning. Participated primary students have to finish three different sorting tasks of classifying triangle shapes within 40 minutes. Each task consists of three different questions which refer to three indicators. The results show that the validity and reliability of ASR are satisfactory: (1) Using exploratory factor analysis (EFC) with oblique rotations finds that these three indicators in ASR can be grouped in one factor and there is 67.13 % of total variance which can be explained. (2) The criterion-related validity between ASR and Raven Progressive Matrices is .22 ($p<.01$). (3) The inter-rater reliability is .92 ($p<.000$). (4) Only two indicators of supporting ideas and transformation reasoning in ASR can predict Healy and Hoyles' (1999) rubric. These results illustrates that ASR can be used to evaluate primary students' geometric argumentation for teachers.

[28O7H-3] The Change of Teacher's Belief in Mathematics Teaching and the Effect on the Learning Attitude of her Students (*A0381*)

Chi-Wei Kao*, Haw-Yaw Shy, and Chung-Chiang Chou
National Changhua University of Education, Taiwan

ABSTRACT This study was to investigate an experienced teacher's change of belief in mathematics teaching in the process of attending a profession developing program in a teacher education institute. And the effect on the learning attitude of her students. The case study was adopted for this purpose. Data collected including interviews, classroom observations, videos of teachings, students' work sheets, and questionnaire. Analysis was carried out by matching the data with the categorization of teaching philosophies. The finding shows that: 1. The vital ingredient a successful profession developing program is the teacher educator who demonstrate .both theoretical proficiency and ability in demonstration teaching in the authentic classroom. So that teachers are able to acquire knowledge and to have the opportunity to make sense of the knowledge by watching the teaching paradigms. 2. Case teacher's mathematics teaching belief has transformed from the passing philosophy to the developing philosophy. 3. According to teacher's belief change, students' learning attitude showed a significant change in affection and behavior of learning. [Draft]

<7I> Integrated (SSI, EE, ESD)
Chair: Su Chi Fang (National Taiwan Normal University)

[28O7I-1] Conceptualizing Socioscientific Decision-Making in Science Education: A Review of Research (*A0106*)

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ABSTRACT The development of decision-making (DM) competence is acknowledged as one important learning goal of science education. Growing in this modern and global society, it is pivotal to prepare future citizens with such competence for making well-informed decisions when encounter complex socioscientific issues (SSI). In the past decades, although SSI was broadly employed as a platform for fostering students' higher-order thinking skills, such as argumentation and informal reasoning, relatively little research focused on socioscientific decision-making. This article proposes a theoretical framework for conceptualizing socioscientific decision making in science education, provides a critical review of current knowledge regarding the research theme, and discusses the issues emerged from this review. Essentially, the proposed framework defines DM as a process involving three phases: formulating the DM space, positing the optimum strategy to make a decision, and reflecting on the DM process. Based on the framework, we set the criteria for selecting the studies that explicitly used DM process as their research rationale during 1995 and 2015. A search of four major international journals in science education using the two key words socioscientific issues and decision making resulted in the initial database (144 articles). After preliminary reading, we found that most of the studies in the initial database used SSI-DM as research contexts, but few of them actually gave a clear definition to the term DM or adopted a DM framework for instructional design. Only 16 articles met the criteria and thus were included for the critical content review. The results show that the studies in SSI-DM had two research lines. The first research line was concerned about the formulation of DM spaces. Related research explored how students employed informal reasoning and reflection to formulate the DM space, and how this competence can be improved. The researchers suggested that using a DM framework to guide discussion can increase students' quality of reasoning, Also, exposing students to different opinions by group members or their counterparts from different cultures might help them become more aware of the values underlying their decisions. In general, these studies valued the process of discussion more than the outcomes and the ways to reach a final decision. In contrast, the second research line emphasized the importance of using a DM strategy to reach a decision. Two different instructional interventions were proposed to enhance students' ability to adopt an optimum DM strategy. One group of studies designed training sessions to support students' reflective uses of three different DM strategies (compensatory, non-compensatory and mixed). The other taught students only one optimization DM strategy and investigated what types of instruction (direct or indirect) better supported students' learning. These two interventions were effective in promoting students' strategic competence. It is noted that they both highlighted the significance of "metadecision" in DM; that is, providing students opportunities to reflect on the outcome and if the selected DM strategy was appropriate for the present situation. Relevant issues emerged in the review such as the roles "value-based reasoning" and "metacognition" play in developing students' DM competence were discussed.

[28O7I-2] The Role of Reading Literature in Promoting Awareness and Action with Regard to Ocean Sustainability: Transportation Experience (*A0111*)

Chi-I Lin
Center for General Education, National Sun Yat-sen University, Taiwan

ABSTRACT Recent research has suggested the potential of using works of art, music, and literature to cultivate students' ability regarding "empathic projection", which leads to insights into complex issues in the lifeworld, in their learning process. Literary works encompass ways of thinking that affect one's consciousness, evaluations and beliefs. Transportation is the mechanism whereby narratives function in engaging the reader in the imagery and affect domains and therefore lead them to become "absorbed" in a story. The aim of this paper is to investigate students' transportation experience of reading literature on topics linked to the ocean which serve as an approach for promoting awareness and involvement regarding marine environmental sustainability. In this study, research data are collected for two consecutive years during the semester of 2014/2015 and 2015/2016. 97 university students from various disciplines enrolled in the interdisciplinary course entitled "Sustainable Oceans", integrating marine science and marine literature. The participants were assigned to read excerpts from texts from marine eco-literature during the course sessions, and their responses to the texts and learning outcomes are assessed using two assessments: (1) the Transportation Scale which contains 11 items on a Likert 7 scale (anchored by not at all and very much)

including cognitive, affective, and imagery aspects; and (2) the participants' emotions and feelings were simultaneously self-monitored using the PANAS Scale (Positive and Negative Affect Schedule). The results show that the participants' emotions and perceptions were consistently affected by the literary texts. Their transpiration experience occurs most significantly in 3 aspects: (1) they were able to "imagine the background/backdrop/scenario of the narratives"; (2) they picture the ending/future of the issues/problems portrayed in the text; and (3) they experience changing emotions in response to the storylines. Based on the findings, the paper concludes that the meaning of sustainability is "personalized" through reading eco-texts entailing environmental issues and lifeworld problems. Also, reading literary works can be tailored as an effective approach to engage both cognitive and affective learning progress.

[28O7I-4] Development of Gaming Simulation in Higher Education for Sustainable Development: A Design-based Research (*A0216*)

Siu-Kit Yeung*, Wing-Mui Winnie So, Nga-Yee Irene Cheng, and Cheuk-Fai Chow

The Education University of Hong Kong, Hong Kong

ABSTRACT The ultimate goal of education for sustainable development (ESD) does not simply aim at knowledge acquisition but also affective (attitude and behavior) changes. Simulation games have been recognized for their potential to achieve multidimensional (cognitive, skill-based, and affective) learning outcomes, which fit the ESD objective. However, how and why simulation games, as an ESD teaching approach, can fortify an individual's knowledge, attitude and behavior towards a sustainable lifestyle have not been fully explored in previous studies. Adopting a design-based research (DBR) approach, the research objectives go beyond proving the effectiveness of one simulation game, but exploring design principles as well as educational theories that can lead to desirable learning outcomes. There are two phases in the current DBR study. Phase I employed a quasi-experimental design to benchmark the effectiveness of the self-designed gaming simulation (GS) with inquiry teaching (a well-recognized teaching approach in higher education). A total of 60 undergraduate students (mainly from environmental science/education related majors) were recruited for an 8-hour plastic waste management training program and randomly assigned to one of the two classes employing different teaching approaches. The research was a pre-post-test design involving the use of pen-paper questionnaires and interviews. Hence, opinions regarding the instructional designs as well as the changes in knowledge (K), attitude (A), and behavior (B) of participants were collected. In terms of K and B, quantitative results suggested that pre-post-test in-group differences were significant in both groups. Significant attitude change was only observed in the GS group. Facilitating and limiting factors of the GS were identified through interviews for phases II refinement. In phase II, another 31 undergraduate students (mainly from environmental science/education related majors) were recruited for the revised GS. By increasing the competitiveness among the participants in the GS design, significant improvements has been identified in K when compared to the phase I GS and inquiry teaching. The pre-post in-group improvements in A and B were also found. Through the comparison and refinement of the teaching approach, key factors in designing effective sustainability program were observed and discussed, which can provide useful implications for other educators.

<7L> Teacher Education

Chair: Wing Yan Valerie Yip (The University of Hong Kong)

[28O7L-1] A Study of Professional Growth for Elementary Teachers' Community of Practice on Nature of Science (*A0064*)

Hsueh-Yun Yu[1]*, Huey-Lien Kao[2], Erh-Tsun Chin[1], and Ming-Chou Su[3+]

1. National Changhua University of Education, 2. National Pingtung University, and 3. Tajen University, Taiwan

ABSTRACT Many research showed that teachers' knowledge and pedagogical content knowledge on nature of science needs to be strengthened. Therefore, the purpose of this study aimed to foster a community of practice, to establish appropriate learning situation, and to adopt implicit and reflective explicit activity-based approach to promote teachers' professional growth from important teaching and learning theories and related research on nature of science in the past few decades. The study lasted three years. The first year of the study mainly developed a model for elementary teachers' professional growth. The study first inquired teachers' professional growth current conditions and needs for nature of science. Then, the study developed curriculum for teachers' professional growth. The second year of the study mainly carried on teaching practice, investigated the important factors of elementary teachers' professional growth and students' learning outcome, and revised the profession growth model. The third year of the study mainly developed an extending model of the professional growth project. Finally, this study extended the teaching curriculum of nature of science through books, network, and workshop etc to promote teaching competencies of teachers on nature of science and learning outcomes of students. The study used Views of Nature of Science Questionnaire-FormVNOS-D2 (Views of Nature of Science Elementary School Version 2) (Lederman & Khishfe, 2002) and VOSI-E (Views of Scientific Inquiry-Elementary School Version (Lederman & Ko, 2004) to know whether the participant teachers grew in viewpoints of nature of science. In addition, this study adopted multiple data to explore professional growth process of members in the community of practice and factors that affected professional growth. Findings of the three-year study confirmed that the teachers have grown in viewpoints and teaching of the nature of science after joining the community of practice.

[28O7L-2] Enhancing Teachers' Understanding and Perceived Roles to Teach Nature of Science (NOS) through the Use of Classroom Videos (*A0231*)

Wing Yan Valerie Yip

Faculty of Education, The University of Hong Kong, Hong Kong

ABSTRACT Effective NOS instruction relies on teachers' understanding and their perceived roles in teaching NOS. Making use of critical incidents is identified as a useful

approach to develop teachers' understanding of what effective NOS instruction means. For instance, Nott and Wellington (1998) used written cases of critical moments to probe teachers' conceptions of NOS before and after joining the teacher professional development (TPD) programme. Nevertheless, "identifying and capitalizing on spontaneous teachable moments in lessons" has remained difficult for teachers (Schwartz & Lederman, 2002). Other than teachers' understanding, another factor affecting NOS instruction is the teachers' beliefs and intentions (Lederman, 1999). Teachers may be unaware of their roles in teaching NOS (Bartholomew, Osborne & Ratcliffe, 2004). Therefore we held two consecutive TPD programmes for the secondary science teachers; and put their beliefs and perceived role as one of our emphases. In the workshops, videos capturing critical moments of NOS instruction were used to elicit teachers' reflection and discussions. In this study, we aimed not only to understand how they would identify 'teachable moments' in classrooms, but also to answer the following research questions: 1. What is the nature and significance of critical incidents in reviewing teachers' beliefs and their perceived roles to teach NOS? 2. In what ways can teachers' reflection be facilitated by using lesson videos depicting critical incidents of teaching NOS? Our data sources mainly came from: (1) the videos of the discussions in both TPD programmes; (2) the written reflection task of teachers completed after the discussions in the second TPD programme, and (3) the semi-structured interviews held right after the discussion and at the completion of the second TPD programme. The findings confirmed that videos capturing critical incidents facilitated our teachers to identify the very fine details of classroom interactions. They were able to notice pedagogically important events and hence to improve their NOS understanding. In our second TPD programme, we guided our teacher participants to reflect on their practices according to the Five Dimensions of Effective Practices (FDP) framework (Bartholomew et al., 2004). Analysis on teachers' comments could exemplify how their beliefs and perceived roles in NOS teaching changed accordingly. Reviewing the videos for at least twice in a collaborative manner also positively influenced teachers in their conceptions and values to teach NOS. Incorporating some of these features would be promising for improving NOS instruction.

[28O7L-3] The Effect of SNS-based Program on Pre-service Science Teachers' Teaching Efficacy (*A0530*)

Lei Gao*, Jungmin Yoo, Eunjin Kim, Soo-A Kim, and Sung-Won Kim+

Ewha Womans University, Korea

ABSTRACT This study investigated the effect of the SNS-based peer support practicum program on pre-service science teachers' (PSTs) teaching efficacy. And it explored the types of the peer supports emerged from their feedback writings. PSTs with higher sense of self-efficacy showed greater enthusiasm for becoming a teacher. Teaching efficacy is a predictor of confirming PSTs' willingness of being a teacher, and well-constructed peer support can be the predictor of teaching efficacy. Student teachers normally encounter initial burn-out experience during their practicum. One of the reasons is that student teachers disconnect with their university faculty and peers, and even sometimes with their School Coordinating Mentors or Cooperating Teachers. It is through peer support that pre-service teachers can develop the capacity for successfully adapting to the real classroom. However, it is hard to face-to-face peer support cause of the limitation of time and distance. Hence, we formulated an online circumstance where PSTs utilized Facebook to exchange peer support period practicum. Therefore, the research questions of this research are: (1) What is the effect of the SNS-based peer support program on PSTs' teaching efficacy? (2) What are the types of peer support that provided to each other while sharing their experiences? A total of 19 female PSTs were required to post reflective journals on a closed Facebook group regarding their practicum experiences, concerns-and-worries, memorable moments, and new ideas for science teaching. And they shared the journals with their peers, simultaneously conducting student teaching at different schools, and replied to them. Total 149 journals and 469 feedbacks were collected for analyzing. Additionally, pre- and post-tests were administered by using the STEBI-B questionnaire, which includes Personal Science Teaching Self-Efficacy (PSTE) subscale and Science Teaching Outcome Expectancy (STOE) subscale. The result of the survey was analyzed by descriptive statistics and Wilcoxon singed ranks test. The results of the study indicated that pre-service teachers' teaching efficacy level was significantly higher than pre-test ($p<.05$). The sub factor PSTE was also significantly increased through this program ($p<.01$). STOE also increased, however, there is no significant difference between pre- and post-test. Nine types of peer feedback were found from this study: (1) accepting emotion, (2) compliment & encouragement, (3) analyzing causes and problems, (4) facilitation of thinking, (5) providing information, (6) sharing experience, (7) advice & suggestion, (8) opinion, and (9) reflecting through indirect experiences. We find PSTs' teaching efficacy level was significantly higher than pre-test. Additionally, we also obtained different types of peer feedback with instructor feedback, especially for the last one, which is 'reflection through indirect experiences'. We suggest that Facebook can be an efficient cyber-space for teacher candidates to actively communicate and to effectively support from each other. This SNS-based peer support program can be useful further in science teacher preparation programs that developing PST's teaching efficacy.

[28O7L-4] Technological Pedagogical Content Knowledge (TPACK) Instrument for Physics Pre-Service Teacher: Framework, Indicators, and Items Development (*A0592*)

Arif Hidayat[1,2] and Kinya Shimizu[1]

1. Graduate School of International Development and Educational Cooperation, Hiroshima University, Japan and 2. Physics Education Department, Indonesia University of Education, Indonesia

ABSTRACT Teacher education program design using Shulman's Pedagogical Content Knowledge (PCK) is inadequate in forming the professional capabilities of future teacher to deal with technology integration to enhance teaching and learning in 21st century. Extending technology and its relationship with content and pedagogy over the framework Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler 2006) become a lens to develop the role of technology integration in teacher knowledge,

including in the context of science teacher. The research aimed to discuss the framework, and define indicators and items development of TPACK instrument for secondary pre-service science teacher. Review of literature examines the development of the TPACK framework (between 2005 and 2015) with a particular focus on assessing TPACK for preservice teacher preparation programs, starting from the framework, instruments and methods as well. Throughout the result of the literature reviews, seven sub-domain of TPACK and its indicators for : Content Knowledge (CK), Pedagogy Knowledge (PK), Technology Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and TPACK itself are developed. The paper discuss the rational and its background on 31 indicators with 116 items according to each domain's framework resulted from this research. The items are ready for further process i.e. validation step and statistical processes to be usable instrument to measure TPACK of secondary school science teacher candidates.

Poster & Special Poster Presentations

POSTER PRESENTATIONS

Poster 1X (26th, 11:30-12:50)

[26P1X-1] Use of Facebook for College Engineering Courses in-class Q&A Activities: Its Effects on Cognitive Development, Affective Involvement and Social Interaction (*A0028*)

Yu-Hsin Liu*+ and Fu-Yun Yu

National Chi Nan University and National Cheng Kung University, Taiwan

ABSTRACT Research has shown that undergraduates tend to have passive learning habits. However, core capacities (e.g., creative thinking, reflective thinking, critical thinking, problem solving, and communication skills) are believed to be better cultivated through active learning experiences, and are essential if graduates are to fulfill their potential in today's knowledge society. It is therefore important to make classrooms more active by integrating activities that facilitate inclusive, participatory, and constructivist learning. To achieve this aim, questioning coupled with the use of Facebook (FB) was adopted to support college engineering teaching and learning. This study then examined the learning effects the undergraduates perceived with regard to the impacts of this approach on the cognitive, affective and social dimensions. Forty-two undergraduates enrolled in a required engineering course participated in this study. A group was created in FB that was used only by the participants and the instructor. The students were asked to bring their own personal mobile devices to participate in in-class Q&A activities via FB. A sequential mixed research method was adopted. First, informal, non-participant observation was used and served as a basis for the development of a scale. As a result, a 20-item five-part Likert-scale was developed to collect data on the students' perceptions of the potential of in-class Q&A activities via FB to support their learning. In addition, one question was included to reveal the extent of changes the participants felt/observed with regard to their attitudes toward attending classes, learning habits and behavior. Data collected at the last instructional session revealed that more than half of the participants (52.63~97.37%) expressed their agreement with each of the twenty statements of the scale. In particular, more than 80% of the participants agreed that in-class Q&A with FB promoted: the quality of interactions and classroom dynamics between and among the instructor and students (97.37%), awareness of multiple perspectives from peers on the topics discussed (97.37%), level of understanding of related issues (94.74%), motivation and interest in the course (92.11%), grasping of main ideas and important issues in the field (92.11%), attentiveness to instruction and classmates' opinions (89.47%), participation and concentration in class (89.47%), critical thinking (89.47%), and forming the habit and ability of sharing and expressing personal opinions (84.21%). Further analysis of the summed up data and each statement, using one-group t-tests with 3 as the expected mean, showed that the results were all statistically significant. Finally, more than 85% of the participants felt that the extent of changes in their attitude toward attending classes, learning habits and behavior were 'tremendous' (10.53%) or 'a great deal' (76.32%). Overall, the results of this study indicated that in-class Q&A with the support of FB promoted and deepened the participants' learning in various cognitive, affective and social dimensions. In view of the widespread use of FB by college students and the need to transform classrooms from places where passive, receptive learning occurs into ones with more active and constructive learning, university instructors are encouraged to experiment with the use of FB to promote active learning communities.

[26P1X-2] CSimulator: Development of an Educational Support Tool for Chemical Experiments (*A0431*)

Shin-ya Takane

Department of Information Systems Engineering, Faculty of Design Technology, Osaka Sangyo University, Japan

ABSTRACT In recent years, high school and junior high school students have a problem, which is called "disinterest in science". One of the main reason for the problem is that they have less and less time for scientific experiments or practices in the curriculum. As a solution for this problem, the efficient use of ICT becomes popular. In particular, smart devices such as iPhone, iPad, etc., attract a great deal of attention as educational support tools. Smart devices have an advantage that they can make learning fun for everyone, anywhere, at any time. From this stand point, we have already reported the prototype implementations of iOS application that simulates the experimental procedure of the funnel extraction or that of qualitative inorganic analysis of metal cations. In this study, we investigate to extend the system for allowing the user to easily customize the application without knowledge of iOS programming. In particular, the users (teachers) can design the experiment (operating procedures, state transitions, etc.) that will be examined by their students. This can be achieved by preparing and accessing an application management server. Redesign of the software structure is also discussed. [Draft]

[26P1X-3] Use the Bit brick and Scratch Program to Make Music by Using the Concord of Audience (*A0524*)

Chanbum Jun*, Hajun Yu, Yeonjong Jung, and Kyungwook Park

Soongmoon Middle School, Korea

ABSTRACT This search is about making a program that people can change the three elements of music by themselves according to the concord of people who listen to music. <Motive and Purpose> Today, works of art such as photos, pictures are changing into digitization. The music is changing, too. Not Just the music changes into sound of machine, 'Make media art work which include thought of computer to perform the music, and moving object from music.' so want to make a product that combine science-computer-art and lead to an interest. <Method 1> We used Bitbrick to rehearse a song, 'Arirang' We save many value of sound variables, and adjust sound about concord of audience Three elements of sound are amplitude, the number of vibrations, and tone color. The amplitude changed about concord of audience. We control the height of sound of music. When we push a touch sensor, height of sound was turned up loud. When we push the other one, height of sound was turned down quietly. Speed of the music was adjusted by potentiometer. If the value of potentiometer becomes bigger, the speed of music becomes

faster, and the color of LED bulb changes into red color. Otherwise, if the value of potentiometer becomes smaller, the speed of music becomes slower and the color of LED bulb changes into blue color. In the case of wave form, all instruments have different wave forms. We chose an instrument that has the best waveform which is suitable with 'Arirang' to achieve the harmony between the waveform and the korean cultural heritage. Three basic elements of sound(waveform, oscillation frequency, and wavelength) in this program is also helpful to learn other educations such as science and music of 2nd grade of middle school. It's not education just by letter but a chance to feel a change of elements by hearing and vision. <Method 2> a wat to analyze the concord of audience 1. If people push two kinds of touch sensors, we can change the pitch by accumulating the value of touch sensors. One is a touch sensor that can higher the sound and the other is what can lower the sound. Since it accumulates the value without no difficult process, it's good to work. But there is one problem that we need too many touch sensors to get the all information of audiences. 2. If people push the same two buttons in our website that updates itself very fast, the value is stored in a place just like memo and these information are operated with scratch program to control the pitch. Although there are no operational budget problems, we should pass through lots of processes. [Effect] : We can concentrate on the music better by listening the music sound which is changed according to our reaction. Through this, we can know the feature of music's variation. Also, it's useful to teach a child who doesn't like the boring classic music to make he or she learn interestingly. For example, if parents make a child listen to a boring music and let him control the volume and the pitch, a child will listen to music with interest. Also, it can be a motivation to raise the basic knowledge and beauty by listening to lots of music. With the side of economics, technicians don't have to change the music by themselves since the music is changed automatically. Also, when we listen to an explanation in the museum, we can control the speed and pitch of the explanation. It means people can get the explanation service better than before. Educationally, it can be used in the class. For instance, if a teacher teaches students "the pitch of sound is because of frequency, bigger or smaller sound is because of amplitude and each instruments have different sounds because of waveform!" Furthermore, nowadays, the music industry is becoming larger and larger. So, we thought that the music should be changed as people like the music much and that's why we started this search.

[26P1X-4] Supporting Primary School Students' Science Learning through Online Student-constructed Tests with Citing (*A0037*)

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ABSTRACT In view of the pedagogical potential of student-constructed tests, an online learning system was developed. Furthermore, in light of observational learning theory and the potential of web 2.0 technology to empower the crowds to remix and re-innovate, the system was expanded by embedding the capability of citing peer-generated questions during the test-construction process. To empirically examine the learning effects of this approach, the comparative effects of online student-constructed tests with citing versus without citing on primary school students' science learning served as the focus of this study. In addition to the cognitive effects of citing peer work, learning anxiety were also examined, as the negative emotions induced by additional in-class learning tasks may have significant impacts on learning outcomes. A pretest-posttest quasi-experimental research design method was adopted. Six fifth-grade classes were recruited and randomly assigned to two treatment groups—online test construction with citing (the experimental group) and online test construction without citing (the contrast group). For the experimental group, by design, students were able to view and include peer-generated questions as part of their online constructed tests during test construction phase whereas for the contrast group students could only use their self-generated questions as a basis for their online tests. To establish a baseline, details of student science performance in the prior learning units were collected. Furthermore, all participants were exposed to the 'without citing condition' first so that data on students' perceived learning anxiety with regard to the exposed learning activity could be collected, before they were exposed to the different treatment conditions. Two science units were covered during the study, and student performance was measured by a teacher-developed posttest meeting item discrimination standard. In addition, a 9-item learning anxiety scale with satisfactory validity and internal consistency was adopted. Data were analyzed by the analysis of covariance (ANCOVA) after the assumption of homogeneity of regression slopes was satisfied. The results of ANCOVA showed significant differences in student science performance, $F(1, 162) = 4.163$, $p = .043$, $<.05$, with students in the experimental group performing significantly better than those in the contrast group. Furthermore, no significant differences were found in learning anxiety, $F(1,161)$, $= .49$, $p = .485$, $>.05$, with both treatment groups exhibiting low learning anxiety. This study is the first work to empirically examine and yield data confirming what is suggested by observational learning theory—that enabling students to view and cite peer-generated questions during online test construction promoted better science achievement and did not induce high learning anxiety. Based on the findings of this study, instructors integrating test construction activities in their class are advised to take advantage of online systems equipped with a citing feature to enhance their student learning of science. Moreover, developers of online learning systems targeting similar learning activities are advised to consider embedding a citing feature to maximize the power of web 2.0 technology.

[26P1X-5] The Virtual Vibraphone with Bit-Brick Module (*A0577*)

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ABSTRACT Many music instruments are loud. So, Common person can't play the music instruments usually, Because That behavior gives public harm to other people. So, We make the virtual Vibraphone. That can change power of sound and It has special point, virtual. It can't play like the piano, so we choose Vibraphone. These are our motivations and purpose. We will introduce our Algorithm simply. If

you click the touch sensor, The program will start. You already to start, you should clap fast or slow. The speed of clap decide the length of sound. If you move finger to IR sensor's range, You can play that like the Vibraphone. If you want to make sound higher or lower, Click the touch sensor again. The octave will change. Also, After start, nobody play the piano during 15 seconds or after the 100 seconds, the program stop. Like the 'Insert the coins!' games. This function gives to people more fun. The students can study music and science (wave) from this. The sound is wave. We can see the waves to the wave programs. And, We can see the 'What is relationship of wave and sound.' Also, music is good for our mind, We can know the what is beautiful sounds from this (harmonys). And We can know the science (wave). We need more time little bit. We change the Variables to English. And If We have more times, We can add something more. The Algorithm is almost perfection. Thank you for reading our plan.

[26P1X-6] Development of a New Student Experiment in Immunology based on ELISA (*A0360*)

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ABSTRACT It is important for all high school students to understand human and animal immune systems because they are closely related to microbial infection and medical diagnostics in our life. Antigen–antibody reactions are core immune reactions in human immune systems. Some previous surveys have revealed that many high school students have great interest in human biology related contents: immunity is one topic of "Basic Biology", which is a biology subject in the senior high school curriculum, the latest national curriculum in Japan, what is called Course of Study. However, student experiments elucidating immune systems especially antigen–antibody reactions, are few. For this study, we developed a student experiment program that lets students confirm how the reaction proceeds is based on visualization of an antigen–antibody reaction by comparison of the degree of solution coloration or measurement of the coloration condition. We used inexpensive reagents, enzymes, and antibody for the reactions and experimental equipment necessary for development. First, we started modifying an educational antibody experiment kit, which includes all the necessary reagents. Enzyme-linked immunosorbent assay (ELISA), which is a widely utilized tool for primary diagnostics in hospital, has been used in biology lesson in undergraduate education. We utilized ELISA Immuno Explorer Kit (#1662400EDU) (Bio-Rad) following previous practice. This report presents experimentally obtained results for shortening the total reaction time. In general ELISA, total reaction requires over 2 hours: 2 antigen-antibody reactions, 3 times washing for each antigen-antibody reactions, and measuring absorbance with spectrometer. We reduced the number of steps and successfully conducted the modified protocol in less than 50 minutes: 1 antigen-antibody reaction using a enzyme-labeling reagent for primary antibody (Western BLoT Rapid Detect v2.0) (TaKaRa Bio) and measuring intensity of solution coloration (not absorbance) with tablet PC application.

[26P1X-7] Explore 6th to 8th Grades Students' Critical Thinking about Environmental and Nuclear Energy Issues by WISE (*A0061*)

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ABSTRACT The purpose of this study is to investigate 6th to 8th grades students' critical thinking about environmental and nuclear energy issues by Web-based Inquiry Science Environment (WISE). In WISE, this study integrated the issues about environmental education into 6th to 8th grades curriculums, such as "divergence and precaution curriculum" and "biology and environmental curriculum". Besides, students need to play opposite roles of benefits to bring up their comments about environmental and nuclear energy questions. There are ninety-seven students participated in this study (6th grade students = 45 students; 7th to 8th grades students = 52 students). The results of this study show that elementary school students can suggest multiple reflect comments, but the qualities of comments are not good enough. On the other hand, the junior high school students' comments are more coherence and higher quality than elementary school students. The further discussions and implications will be discussed in this study.

[26P1X-8] Development and Evaluation of STEM Activities in Magnetic Force and Faraday's Law Topics (*A0511*)

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ABSTRACT This study has two objectives. The first objective was to develop STEM activities in magnetic force and Faraday's law topics. Two STEM activities including magnetic train and magnetic flashlight were constructed and taught with a guided inquiry approach. The second objective was to evaluate student understanding before and after learning with STEM activities and to assess their problem-solving skills. Participants were 28 Grade-10 students from a high school in Phuket, Thailand. The first author was teaching these two activities after students learned physics on topics of electromagnetism and each activity took about three hours. The one group pretest–posttest design was employed in carrying out the study. The instruments included two conceptual tests emphasized magnetic force and Faraday's law. Student responses on both conceptual tests were analyzed using a pair-sample t-test and normalized gain. For the magnetic force conceptual test, there was a significant difference in the post-test scores (M = 9.0, SD = 2.8) and the pre-test scores (M = 6.5, SD = 2.9); t (27) = 8.53, p = 0.0001. For the Faraday's law conceptual test, there was a significant difference in the post-test scores (M = 14.2, SD = 3.2) and the pre-test scores (M = 11.0, SD = 3.7); t (27) = 9.82, p < 0.0001. These results suggest that learning with the STEM tasks really does have an effect on student conceptual understanding in electromagnetic concepts. The average normalized gain from the magnetic force topics was in the low gain <g> = 0.29, whereas the Faraday's law topics was in the medium gain <g> = 0.39. These results indicated that the students did understand magnetic force and Faraday's

law concepts better after the activity. In addition, students improved in their problem-solving abilities after doing the magnetic flashlight activity. Students also satisfied with learning from these STEM activities and suggested that there should be more of this kind of activities to help improving their physics understanding.

[26P1X-9] Development of Higher Performed Dye Sensitized Solar Cell Model Cars Equipped with a Pulley-rubber Band System (*A0123*)

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ABSTRACT The Great East Japan Earthquake (March 11, 2011) triggered citizen's awareness and attention to renewable energy and needs for energy education for the next generation. While the current Course of Study of upper secondary school in Japan made emphasis on the importance of understanding of the nature and use of renewable energy, through inquiry-based activities, teaching materials on renewable energy are still rare. Our laboratory, so far, has been developing experimental materials utilizing Dye Sensitized Solar Cell (DSSC), which students themselves could make safely in science lab classes without any special apparatuses or equipment, and trying to evaluate their educational effects. Our group had been in success in running tests of model cars equipped with DSSC, and we found that individual 9th grade students were actively involved in practical activities (making the model cars and running trials). Thus, the model cars equipped with DSSC are an attracting experimental material for high school students. This study aimed to develop lower-cost model cars, which enabled schools to adopt. For this purpose, we tried to make DSSC model cars, replacing a high-cost 'gear' system with a low-cost 'pulley-rubber band' system. It was necessary for the 'pulley-rubber band' model cars to mount solar cells with more efficient power generation than those of the 'gear' model cars. Firstly, we succeeded to improve and maintain the capacity of solar cells by inserting filter paper between polar plates. Secondly, using the improved solar cells, we made model cars with a system consisting of pulleys (produced by a 3D printer) and a rubber band successfully. We achieved, reducing the total cost of making this model car by about 1,000JPY. This paper reports the developmental processes, the nature and the capacity of this improved solar cells and model cars.

[26P1X-10] Development of a Low-cost Experiment Set Enabling Learners to Experience the Renewable Wind Energy and the Hydrogen Fuel Cell (*A0281*)

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ABSTRACT After the Great East Japan Earthquake in 2011, Japanese people have paid special attention to renewable energy as an energy source not only safe but also improving the energy self-sufficiency rate. The number of patent applications of hydrogen fuel cell of Japan is top of the world. So particularly in Japan, resource-saving and CO_2-free hydrogen fuel cell is advanced. Up to the present time, home-use fuel cell system and fuel cell powered vehicle has begun to be widely used in Japan. On the other hand, under the current circumstances, most of hydrogen gas itself is produced from a fossil fuel. In response to this situation, the Ministry of Economy, Trade and Industry is aiming to establish the perfect CO_2-free hydrogen-supply system until 2040. So, in order to nurture future scientists who will work on this urgent problem, required is popular teaching materials, helping them to learn renewable energy and hydrogen fuel cell. But at present, unfortunately, these materials available are too expensive for ordinary schools to afford. Then we have developed a desktop type Savonius-type wind power generator (Kawamura, 2013) and fuel cell teaching materials (Nosohara, 2006). In this paper, we present the developmental process of the experimental set enabling learners to experience a series of flow in which renewable wind energy is changed into electricity through hydrogen. Moreover, this set costs only about 1000 JPY, which is much cheaper than the conventional ones. This new method is to use fuel cell pole plates, which plated big bamboo charcoal and steel wool that has great surface/volume ratio with palladium. In addition, it is possible to charge hydrogen by a desktop type Savonius-type wind power generator. It was shown as a highly valuable teaching material, fitting to the teaching unit, "Energy" (9th graders' science class) and "Energy and its practical use" (high school basic-physics class), which are particularly emphasized in the new Course of Study of Japan.

[26P1X-11] Development of an Automatic System Measuring Water Temperature and Flux of Insolation of a Movable Water Heater Made of PET Bottles (*A0088*)

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ABSTRACT Japanese people are more concerned about the natural energy use than ever, after the Great East Japan Earthquake in 2011. Among others, systems of solar power generation have been introduced in community life. In some systems, natural energy is utilized by transforming it into electric energy. Other systems, in which water is heated by thermal energy derived from sunlight, is popularly used as a part of house equipment. Practical activity of making warming water by sunlight is instinctively understandable for elementary and lower secondary students, and it can serve as an excellent teaching material for natural energy use. Also, reuse of PET bottles and iron angles is educationally meaningful. We proposed a movable water heater unit with 24 two-liter PET bottles (total 48 liter tank). By combining three or four units, we can store 150-200 liter of hot water at hand. It affords, for example, the hot water for one person to take a bath. We can think of various kinds of ideas to utilize the hot water made by the heater in the occasion of disasters as well as in our ordinary life. In this study, we monitored water temperature, air temperature and flux of insolation. Their correlations were examined in order to identify the characteristics of warm water generated in a unit of the movable water heater. The monitoring apparatus, an Arduino, a general-purpose board, pretreating signals from such sensors, sent them to a data logger (an off-line Windows XP machine), which stored the data. The present poster presentation exhibits the movable water heater, and reports how the measuring system was developed.

[26P1X-12] Kawamura's Top: A Promising Revision by Utilizing Parts Printed by a 3D Printer (*A0208*)

Yasufumi Kawamura
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ABSTRACT While experimental materials for energy and environmental education have been devised and proposed, the number of such materials is still small. Kawamura's Top (Kawamura, 2013) was developed as an experimental tool for learning 'eddy current' utilized in electromagnetic ranges in energy and environmental education settings. In the case of the Benham's top, which is much more popular tool, since the axis of the top should be rotated by fingers, (1) the rotation is too fast to appear a unique color pattern and (2) the top cannot keep the appropriate rotation frequency, resulting in reduction of rotation and finally it stops rotating. However, since the Kawamura's Top enables the Benham's top to keep rotating in a stable rotation frequency, a colored top on the Kawamura's Top can produce and keep a stable mixed color. A Zoetrope on the Kawamura's Top can also rotate a stable rotation frequency, resulting in a good picture. Thus, the Kawamura's Top is an excellent tool for such occasions. The original Kawamura's Top was constructed by various kinds of familiar materials and welcomed as an enjoyable tool, but sometimes cheaper materials were not available. In order to resolve the problem, we propose to use the parts of the Kawamura's Top, printed by a 3 D printer. The printer can print many copies of the parts without deteriorating in quality and accuracy.

[26P1X-13] Conceptualization of a PCK Framework for Teaching Socioscientific Issues (*A0209*)

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ABSTRACT Although most of science teachers admit the necessity and importance of addressing socioscientific issues (SSI), not a small portion of the teachers still hesitate to implement SSIs in their science classrooms. The major reasons of unwillingness to teach SSIs include lack of content knowledge related to SSIs, lack of confidence in using diverse instructional strategies (e.g. discussions/debates, role play, etc.), insufficient curriculum resources, lack of students' maturity to handle ethical and moral aspects of science, and unfavorable school and community cultures. It shows that the teachers need to obtain basic pedagogical content knowledge in order to take their first step toward SSI teaching (SSI-PCK). In this study, therefore, I attempted to conceptualize SSI-PCK by identifying major components and sub-components of SSI-PCK and exploring the dynamics among the components. To achieve the aim, first, I conducted extensive literature reviews on SSI teaching and PCK. I initially identified five components of SSI-PCK. Second, I recruited four science teachers experienced in teaching SSIs, and conducted 2-3 times of in-depth interviews. The teachers brought up various issues such as major emphases of their SSI teaching, challenges of designing and implementing SSI lessons, students' reactions to the SSI lessons, and perceptions of their niche in schools and local community. The interviews confirmed the five components of SSI-PCK and contributed to identifying sub-components. Third, I observed their science classes, with video-taping, when they implemented SSI lessons in order to explore the dynamics among the components of SSI-PCK. Carefully watching the video-tapes, I selected meaningful episodes that showed the examples of interactions among the SSI-PCK components. Results indicated that SSI-PCK included five major components: 1) Orientation for Teaching SSI (OTS), 2) Knowledge of Instructional Strategies for Teaching SSI (KIS), 3) Knowledge of Curriculum (KC), 4) Knowledge of Learning Context (KLC), and 5) Knowledge of Students' SSI Learning (KSL). OTS refers to teachers' instructional goals and intentions for teaching SSIs. Teachers often presented a) activity-driven, b) higher order thinking skills, c) citizenship, d) activism, e) application of science, and f) nature of science and technology orientations. KIS indicates teachers' instructional knowledge required for effectively designing and implementing SSI lessons such as a) constructing SSI situations and sequence of lessons, b) utilizing progressive instructional strategies, and c) constructing collaborative classroom cultures. KC refers to teachers' knowledge on a) connection to science curriculum (horizontal /vertical), b) connection to other subject matters, and c) SSI curriculum materials. KLC refers to teachers' knowledge on the cultures of a) schools and b) community and society where they are located when teaching SSIs. Finally, KSL refers to teachers' knowledge on a) students' difficulties in dealing with SSI, b) students' SSI informal reasoning patterns, and c) students' attitudes, interests and motivation for SSI. Among the five components, OTS was the most influential one that interacted with KIS, KC, KLC, and KSL. For instance, teachers' OTS affected their ethical or moral framing of SSI problem situations and on their use of instructional strategies to maximize the educational effects.

[26P1X-14] A Joint Research between Salesian Polytechnic Tokyo and Mongol KOSEN on Development of Hydroponic System Using the M2M/IoT Technology (*A0391*)

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ABSTRACT The temperature of Mongolia is around 30 degrees below zero during the winter season. For that reason it is difficult to cultivate vegetables with stability in Mongolia. Therefore, our research is focused on hydroponics. In this study in collaboration with the Mongol KOSEN we have made a Hydroponic system using the M2M/IoT technology. Measurement data is sent to a computer using XBee. The measured collected data are based on temperature, humidity, and LED source luminance, which is measured by Arduino. In addition, with a Hydroponic machine, using Processing Programming Language was possible to manage Arduino, and it made possible to measure temperature, humidity, LED color control in the remote monitoring on the computer. Therefore, through Hydroponic system connecting the computer to internet we were able to save the measurement data into CLOUD service. With the usage of this system, we were able to compare the old and new data, in order to establish a perfect environment for the cultivation. The secondary purpose of this study is to aim at bringing up cross-cultural competency and the international knowledge required for an engineer to be. In addition, job opportunities for graduates from higher education is insufficient in Mongolia. Therefore, this study

reveals the necessity to bring up an entrepreneur system between both countries. This presentation is to report the joint research between Salesian Polytechnic Tokyo and Mongol KOSEN which is developing a Hydroponic system using the M2M/IoT technology.

[26P1X-15] Our Community Park Improvement Project: A Case of Subjects Integration through PBL in Elementary Pre-service Education (*A0566*)

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ABSTRACT The need for approach to integrating science with multiple subjects has been emphasized for a long time. Elementary teachers who teach several subjects need the ability to consider a curriculum collectively and to implement it in their classroom, and pre-service elementary teachers need to experience the integrated subjects classes. Accordingly, the integrated project based learning was conducted to 13 students who major in science education at Cheongju National University of Education for five weeks. The title of PBL was 'Our Community Park Improvement Project'. Students visited two parks near their campus, identified the problems of the parks, listened for some opinions from visitors including students and residents, established the concept of a community park on their own, and then presented and peer-reviewed their park design and improvement plan. During the peer review activity, students realized that problem analysis and resolution were appropriate, and that their presentation of improvement plan was done efficiently. However, experts came to the conclusion that they were somewhat short of the creativity of problem-solving ideas and the presentation of concrete solutions through the process of scientific inquiry. As a result of activities, students responded that they found the project learning difficult but interesting, and that their attention to integrated subjects classes and learner-centered learning increased. The students' working process and their outcome will be introduced and then educational implications will be discussed in the presentation.

[26P1X-16] Exploring the Sustainable Ocean Education of a Major Marine NGO in Taiwan in Light of Social Learning (*A0308*)

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ABSTRACT Although Taiwan is an island country, people are not familiar with oceans. It is because that people are banned from many maritime activities for a long time in the period of martial law. Unfamiliar with oceans, people are also lack of ocean science literacy and do not concern sustainable issues about ocean. The government makes effort to increase literacy of marine science and awareness of sustainable issues of people in the recent years. Kuroshio Ocean Education Foundation is one of major NGO devoted in the area of ocean and dolphin issues and education. The purpose of this study is to explore themes, process and approaches of sustainable ocean education of Kuroshio Ocean Education Foundation. In the study, participatory observation, documents review and semi-structured interview were conducted to collect data. The period of research is from August, 2014 to June, 2015. The result showed the context of marine ESD of Kuroshio Ocean Education Foundation includes four themes: ecology of dolphins, animal protection, marine waste and culture of ocean. The learning process of its members has four stages: initial stage, exploring stage, mature stage, and supportive stage. The main approach of the sustainable ocean education could be described in the perspective of social learning. The study provided implication of sustainable ocean education for the government and educators. [Draft]

[26P1X-17] A Worksheet that Leads to the Scientific Concept (*A0085*)

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ABSTRACT It is commonly believed that most children think "Light goes far at night, but light stays on the light source in daylight." and "Light is its source and its effect". Both are conceptions of living that children get from experience every day. On the other hand, in learning about "Light", seventh graders are taught to draw a path of light with a straight line. Because light is recognized as a distinct entity, located in space between its source and the effects it produces. However, this scientific concept is not accepted by the child who does not consider light as an entity moving in space as I mentioned before. For this problem, as the case study about the conception of the junior high student about the movement of light, the purpose of this study is to clarify that the worksheet made for promoting the constitution of the scientific concept of the child have an effect. An investigation was carried out on 174 first graders at a public junior high school from October, 2015 to November. Before and after learning with the worksheet, the students answered two questions about the distance which light traveled from the candle, and the differences in two results was analyzed. After learning about reflection and refraction of light and about convex lenses, a confirmation test for students was carried out and the result was analyzed. It became clear how children think about "The sight" of an object by their replies to the questions on the worksheet. Most of them think that a smooth surface such as a mirror reflects light, but that a rough surface such as an apple does not reflect light. In addition, they think that they can see an object of which the surface is not smooth like an apple if the object is lit up, though they can't see the object in complete darkness. Then they noticed these two views contradicting with each other, and changed into the view that all objects which they can see reflect light. And the child found that we could see the object because the reflected light arrived to our eyes. In the investigation after the worksheet, both of the night and day, the number of children who chose "The light from the candle comes out until it hits something", increased over the same investigation before the worksheet. These observations indicate that most of children came to consider light as an entity moving in space. And then, in learning about reflection and refraction of light and about the convex lens, it followed that the child with a scientific concept of light, got the result that the confirmation test was enough over other children. These findings indicate that learning with the worksheet had a certain effect to promote the constitution of the scientific concept.

[26P1X-18] An Academic Survey in Physics and Chemistry at Lower Secondary School for Gifted and Ethnic Students in Laos (*A0038*)

Yukio Terashima[1*+], Houmphanh Khanthavy[2], Banchai Malavong[2], Kaori Kitano[1], Ayana Oki[1], Takahiro Niinobe[1], Jin Yamauchi[1], Hiroyoshi Nakanishi[1], Kazuyuki Tamura[1], and Takeshi Kozai[1]

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ABSTRACT Lao People's Democratic Republic (Laos) is one of developing countries that are now focusing on their educational reform. To find academic issues with Lao students, we studied Lao student achievements in Physics and Chemistry at lower secondary level by using 29 selected questions from Trends in International Mathematics and Science Study (TIMSS) 2011. For the convenience of marking and analysis, the achievement test mainly consists of multiple-choice questions. This test includes basic scientific concepts of physics and chemistry for lower secondary students such as change in states of matter, light and sound, chemical change, and so on covering basic knowledge and its applications across the two fields. Our survey was conducted at the secondary school for gifted and ethnic students (G&E) attached to National University of Laos in Vientiane capital in December 2014 with a total of 67 students from 8th grade. The G&E students are excellent students selected from all over the country including not only urban areas but also every rural minority races. They study all subjects based on the official curriculum of Laos in the same manner as other public schools. We analyzed the average correctness of the G&E students, and compared them with the scores of other public schools in Vientiane and Japanese and international averages. We found that although the achievement of the G&E students is better than that of other Lao schools, there still is a huge gap in science achievements between Laos and Japan/other developed countries. Especially, the Lao students score poorer in Physics rather than in Chemistry and their reasoning and applying skills are lower than knowing (or knowledge). We also identified their strong and weak points on different learning topics specifically. Most of the students have hard time correctly to understand some physical concepts such as thermal expansion, change in states of matters, properties of light, energy transformation and gravity. On the other hand, they have adequate achievements in classification and composition of matters. We therefore conclude that these academic characteristics originate from learning-teaching methods and contents in Lao science education.

[26P1X-19] Exploring Seventh Graders' Performance in Arguing-about-Science News Instruction (*A0040*)

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ABSTRACT Literature indicates that gender and background conceptual knowledge are crucial factors for middle school students' performance on arguing about science news articles. However, group discussion might inspire learners' scientific reasoning about science news articles, moreover, activation of related content knowledge could promote learners producing better arguments. In this study we recapitulated related content knowledge, encouraged group discussion on questions raised by their peers, coordinated within group conversations and labor distribution, focused student's attention on developing connections among science concepts in written forms, and facilitated peer questioning while students presenting in the whole class. Eighty-four seventh graders from three classes participated in this study. First of all, the content of Nutrition unit in the textbook was mapped out. Science news articles related to the amount of calorie supplied by various nutrients were then selected from news and popular science websites. The news articles were analyzed in terms of the data, claim, and logical connections between data and claim embedded in the articles. Worksheets with sequenced articles were prepared for students to study. A writing frame modified from Toulmin's argument pattern was also provided for students to formulate their argumentation. During the Arguing-about-Science News Instruction, the steps were- students read through the articles, discussed their understandings in small groups, clarified science concepts in whole class sharing, and wrote up their written arguments by recognizing the data and claim elements in the news and producing approval and against reasoning by making connections to related science knowledge. Data sources included measures on the First and Second Examinations, and artifacts of written argument about science news. The teacher-made examinations were composed of fifty test items covering the teaching content. One school teacher developed the items, and then inspected by another colleague in the same school. Codes for elements of argumentation included data, claims, supportive reasons, and rebuttals. Two trained coders coded the artifacts independently and discussed the results to reach agreement. The results of ANOVA indicated that high achievers outperformed low achievers on total argumentation scores; nevertheless, students with difference background knowledge performed similarly on the four argumentation elements. Furthermore, the girls outperformed the boys on identifying warrants provided in the news article. The results of regression analysis revealed that the claim, rebuttal, and total argumentation scores predicted the students' Second sectional exam score. For the boys, their data, claim, self-generated rebuttal, and total scores predicted their Second sectional exam score. For the girls, their score of self-generated rebuttal predicted their Second sectional exam score. We conclude that the Arguing-about-Science News Instruction is beneficial for different groups of students in different aspects. Implications for educational practice will be discussed.

[26P1X-20] Designing a Bridging Science Summer Program for New Junior High School Students (*A0042*)

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ABSTRACT Students transiting from elementary schools to junior high schools frequently suffer from the distinct demand for learning science content. It has been proposed that thematic instruction can stimulate the students' motivation and promote their conceptual understanding. The purpose of this study was to design the thematic instruction "Knowing campus plants" and to evaluate its effectiveness. This thematic instruction created

inquiry-based learning environments and focused on students' understanding of plant concepts. The research team analyzed plant related concepts in textbooks for elementary schools and for junior high schools to organize subject materials and design instructional activities. One hundred and twenty-one seventh grade students from one public suburban school in Taiwan participated in the study. The research team grouped the students heterogeneously based on the students' scores on a test of Biology Cognitive Preference. The teacher guided and supported the students in a series of structured inquiry activities including making observations, keeping a journal of plant forms, studying plant classification, categorizing plants, and making inferences about the relationships between the forms of plants and the ecological environment. The students accomplished the learning tasks through collaboration and discussion in groups. The Plants-Related Knowledge Test was developed and reflected the content knowledge covered in the instruction. After a pilot test, the test was finalized with test items in factual, conceptual, and procedural knowledge from plant morphology, plant physiology, classification, and ecology. Paired-t test and analysis of variance (ANOVA) were conducted to determine the effectiveness of the instruction. Analysis results revealed that the thematic instruction can improve overall performance of the students ($p < .001$). Different achievers' measures on the Plants-Related Knowledge Test were also enhanced ($p < .001$). Moreover, underachievers made more progress than high achievers ($p = .01$). It is suggested that students' participation and interactions in groups can be promoted in a challenging and interesting learning environment, and thus achieve better learning performance.

[26P1X-21] Image of Chemistry for New Students Probed by "Concept Maps" (*A0242*)

Hajime Tanaka[1]*[+] and Tetsuya Suzuki[2]

1. Shumei University and 2. Tokyo Future University, Japan

ABSTRACT In recent years we have been interested in multiple kinds of Science literacy, particularly in those that have demand for Science educators. For example, we want to make it clear to what extent Science literacy should be detailed for Science teachers in school. The "Concept maps" show a possibility to lead the contour of this literacy of Science teachers. At the outset, in 2014 and 2015, Tanaka made the first year students draw concept maps. This was both at the first and last lectures of "Chemistry: An Overview", also at the first lecture in April 2016. The lecture is almost always limited to the course of Science, Department of education in our university. Planning on continuing and investigating concept mapping, we may detect what the students will acquire in the process of being Science educators, or we will know the difference between the maps in the course of Science with ones in other courses. In this report, we tell that the students have a strong impression of the concreteness of the "Experiment" at the entrance to the university. We expected at first the concept maps would show the significance of critical conceptions concerning "Particle Model", "Periodicity", "Physicality" and so on. Because they had started learning on Chemistry with these ideas in junior and high schools. However, it can be seen in their concept maps that students showed stronger impression on "Experiment" than those on any other concepts. We can also tell that the maps of students attach little weight to macroscopic concepts in comparison with the other topics on Chemistry. It means that the students appreciate not so much value of macroscopic concepts as Chemistry educators do. Here we can then reach the following conclusions: 1. "Experiment" is very impressive and educational, because of its concreteness, but the existing method of "Experiment" does not succeed sufficiently in Chemistry Education. We should make a better use of the "Experiment" to show students the significant and abstract conceptions. 2. Higher education or Chemistry education in universities should place more emphasis on macroscopic concepts. We may be also able to use "Experiment" for this purpose. In the maps at the last lecture shows that through "Chemistry: An Overview" the students were impressed with "Van der Waals force", "Atom model", "Hybrid orbital", which are attributable to microscopic concepts, but not with macroscopic ones. We treated macroscopic topics after microscopic ones, and then time might run out to show them the macroscopic concepts. Otherwise, transmitting concepts may be harder in macroscopic region than in microscopic one.

[26P1X-23] Research on Development of a Collaborative Learning Model using SNS (*A0556*)

Sungwon Seo[1]*, Heebok Lee[2+], and Yungseon Seo[3+]

1. KAIST GIFTED, 2. Kongju National University, and 3. Seoul National University of Education, Korea

ABSTRACT Social network activities among mobile users are increasing, due to widely supplied mobile devices such as smart phones and location-based services which allows people to communicate anywhere in the world. In this study, discussion learning model was suggested based on an experiment using Facebook group, for this experiment, an application which extends functions of Facebook groups was developed. Students of four countries; South Korea, Japan, Taiwan, Singapore, found out a way to measure the circumference of the Earth without errors through analysis and discussion on experimental data after using Eratosthenes' method. Especially, collection of data and discussion was done by "STEAM app" which was developed for this study. The developed "STEAM app" was used as a medium for real-time communications to aid learners to solve problems, and it can boost academic achievement as well as interest in learning through real-time interactions and feedback. As a result, students were satisfied with the discussion using Facebook group and "STEAM app". Also, result of regression and perception of collaboration among the students influenced the experimental progress positively. Therefore, discussion learning model using SNS that was suggested in this study was found to be effective. [Draft]

[26P1X-25] The Construction of a Teacher Training Programme Combining and Integrating Science and Technology (*A0046*)

Keiji Gamoh*[+] and Hirotaka Doho

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ABSTRACT The complementary relationship between science and technology has deepened in recent years with consequences for our social infrastructure. "Science" and

"technology" have been taught as independent subjects in Japanese junior high school education, however the implementation of classes which combine and integrate science and technology may make it possible to develop the ability to apply the laws of nature to solve specific problems and to design and manufacture on the basis of scientific laws. In this study, we attempted to construct a teacher training programme for students which develops opportunities to integrate science and technology education and to set up a programme for the teacher training curriculum. We have organized the "Science and Technology Education Course" in the teacher training course of the faculty of education, Kochi University, in 2014. The content of the programme combined and integrated science and technology and subjects and teaching methods were integrally managed and systematically configured. On the basis of the programme, we have developed teaching materials and practical lessons specific to the curriculum, which were applied and continuously demonstrated. The result is the suggested applicability of the programme and its usefulness for developing science and technology education in future. As an example of a practical class combining chemistry and technology, we introduce and demonstrate the planning and manufacturing of an automatic measuring instrument for temperature, pH, etc., its practical application to a chemical experimental and its practical use for a science class investigation in junior/senior high schools. The teachers, who have learned the specific programme in the teacher training course, can ferment their literacy of science and technology and provide and educate a school curriculum combining and integrating “science” and “technology” to the junior/senior high school students.

[26P1X-26] Inquiry and Investigation using Plant Materials in High School Basic Biology Textbooks (*A0417*)

Kana Kobayashi, Kasumi Miyazaki, Kiyoyuki Ohshika, and Juntaro Kato*+

Faculty of Education, Aichi University of Education, Japan

ABSTRACT In the new course of study revised in 2009 by MEXT, high school biology changed from Biology I and Biology II to basic Biology and advanced Biology, and the contents of basic biology also changed drastically. However, the experiment, observation and investigation activity using plant as materials were impressed lower than that of animals. Therefore, we investigated the contents of experiment, observation and research investigation performed with plant as material in four textbooks of high school basic biology published from different companies. Among all experiment, observation and investigation activity in basic biology textbooks, half of all contents were used as plant materials. Among four textbooks, observation of cell and somatic cell divisions were treated in common activity. In the content of photosynthesis, two textbooks were focused starch synthesis detected by iodine solution, two textbooks were focused absorption of CO_2 detected by pH indicator. There are no experiment, observation and investigation in one textbook. In the contents of plant pigment, tissue localization was focused on two textbooks and either one textbook treated with chromatography experiments and another one treated with visual color change of anthocyanin pigment depended on pH. In alien plant from abroad, habitat survey of dandelion were written in two textbooks. Differences of experiment, observation and investigation contents between biology I and basic biology were discussed.

[26P1X-27] Inquiry and Investigation Using Plant Materials in High School Biological Textbooks (*A0418*)

Kasumi Miyazaki*+, Kana Kobayashi, Kiyoyuki Ohshika, and Juntaro Kato

Graduate School of Science Education, Aichi University of Education, Japan

ABSTRACT In the new course of study revised in 2009 by MEXT, the concept of Biology science in high school was shifted dramatically and biological contents changed from cell biology to life science according to rapidly development of life science. To develop scientific knowledge and thinking of students, the guideline of new course of study in science was written that activities of experiment and observation were more enriched than before it. Therefore, we investigated contents of experiment, observation and investigation activity using plant as materials in high school textbooks of advanced biology published by four companies in Japan. Average number of all experiments, observation and investigation activity among four textbooks were 36.0 and average number of that using plant as materials was 14.8. The contents using plant materials were involved inquiry activity (average 11.5) and investigation (average 3.3). Although there were the same inquiry activities in a chapter, different materials (animal or plant) were used among different textbooks. For example, in the observation of cells, while Egeria densa (Brazilian water weed) was used in three textbooks, another textbook used amoeba in same chapter. In the content of alien species from abroad, a textbook was used only invasive alien plant (ex. Gymnocoronis spilanthoides, Pistia stratiotes and Alternanthera philoxeroides) as observation, another textbook was used invasive alien plants and fish as investigation and there were no inquiry activity and investigation in other textbooks. In the chapter of the reaction to environment of the plant, although this chapter is main chapter of plant, there was little inquiry activity using plant for materials in all textbooks. These results suggested that inquiry activity and investigation using plant materials were relatively lower. Especially, in the chapter of the reaction to environment of the plant, inquiry activities or investigations might be needed to understand more this content.

[26P1X-29] Application of Inquiry-based Science Assessment Questions on Earth Science Content Domain (*A0142*)

Young-Tae Kong

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ABSTRACT This study is to incorporate inquiry-based questions in science assessment and analyzes student’s responses in purpose of evaluating scientific inquiry abilities of fifth and sixth grade students in Korea. It aims to assess students’ performances on inquiry-based evaluation and to develop guidance on teaching for development of inquiry skills. This study focuses on the result about an earth and universe domain. To fulfill the research goal, the study is carried out as followed. The chosen research subjects were 421 fifth and 777 sixth graders from seven

elementary schools in Korea. The assessment questions were devised by modifying and reinforcing the NAAA developed by NIER (Japan) to incorporate inquiry-based learning and correspond to 2007 amendment of national science education curriculum in Korea. The following conclusions were made from this study. First, if the most ideal form of learning scientific knowledge is in making scientific inquiries, inquiry-based assessment would be the most appropriate assessment method for fulfilling the ultimate goal of science education as the inquiry-based assessment encourages students to naturally learn not only the scientific information and concept but also the inquiry skills. Second, because this study targets only fifth and sixth graders who have yet to finish the coursework for completion of the education curriculum, the assessment in this study is limited in fully testing students' inquiry abilities. The study should continue on until target students finish all the coursework to observe the change in their inquiry abilities.

[26P1X-30] Study of Using Computer Educational Games to Improve Students' Learning of Scientific Concept and Scientific Argumentation (*A0406*)

Chen-Yu Chen* and Yu-Ling Lu+

Department of Science Education, National Taipei University of Education, Taiwan

ABSTRACT Results from recent international assessments, such as TIMSS and PISA, showed that students in Taiwan are in a need of enhancing their interest and achievement in science learning. Educational computer game has been used to assist students 'science learning and its potential has been shown in many facets of science learning. This study is to develop an innovative approach of using an educational game, which allows groups of students to compete their scientific understanding, to help students to learn science. This study also examines its effectiveness of improving students' learning in "scientific concept" or "scientific argumentation". For the purposes of exploring the difference between learning through educational computer games and learning through conventional teaching, two instructional strategies relating to "Light" for fourth grade elementary students were developed. The research subjects were 4 classes totaling 115 fourth grade students from an elementary school in Taipei; two classes were the experimental group, while the two others were the control group. After 15 class sessions of instructions during a five-week period, students' performances, in terms of "scientific concepts" and "scientific argumentation", of the two groups were measured and compared. This study also examined how these two approaches affect students with different learning abilities. For this purpose, top 27% of science academic performance was assigned as the high achieving group, bottom 27% as the low achieving group, and the remaining students were assigned as the medium achieving group. Assessment instruments were examination for "scientific concepts" and examination for "scientific argumentation". These assessment instrumental were reviewed and developed by two scientific education graduate students, three in-service teachers, and an expert of science education to establish content validity. The reliabilities of these two examinations were assessed by pre-tests, of which 82 fifth grade students resulting in a KR20 coefficients of .80 and .81 respectively. The dependent t-test and analysis of variance (ANCOVA) were used to compare the pre-post test results of both groups to evaluate the learning performance differences. ANOVA was also used to compare the difference in learning effectiveness for the scientific concepts and abilities of scientific argumentation of students with different achievement level. Study results indicated that: 1. Students learned through educational computer game significantly outperformed students learned through traditional instruction, both in "scientific concept" and "scientific argumentation." 2. High achieving students in the experimental group performed better than those in the control group in terms of "scientific argumentation" but there was no significantly difference in terms of "scientific concepts". 3. For medium and low achieving students, the learning performance of the experimental group in terms of "scientific concepts" and "scientific argumentation" were both significantly better than those of the control group. 4. Both in "scientific concept" or "scientific argumentation", students received educational computer game learning approach, regardless low, medium, and high achieving students, showed no significant difference in terms of learning growth. Thus, it is concluded that learning through computer educational games can as effectively increase the learning achievement of medium and low achieving students as that of high achieving students. Some scholars pointed out that curriculums that lack interest or challenge could lower student willingness to learn and result in the phenomenon of high intelligence quotient students with low achievement. Other studies indicated that utilizing computer educational games into science education could effectively assist low achieving students to learn by increasing their interest and reducing their frustration when learning. This study and the results also clearly reveal these phenomena.

Poster 1Y (26th, 11:30-12:50)

[26P1Y-1] Edible Science Experiments for Students: Making a Rainbow Herbal Tea without Food Additives (*A0343*)

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Tokyo University of Science, Japan

ABSTRACT In this presentation, we study various edible science experiments. The reason for doing so is to heighten students' interest in learning through eating. In fact, in Japan, edible science experiments are already included in the science textbooks for elementary and secondary education, e.g., books by Karume-Yaki and Amazake. Moreover, in foreign countries, making an edible rainbow using the difference in the densities of sugar solutions has been reported. However, food additives have been used in these cases. As a part of our research, we attempted to develop additive-free edible teaching materials in the experiment. Here, we describe a method for making rainbow herbal tea without using food additives. Such a method has not yet been known or used. We then attempted to verify the impact of the experiment on education. (1) Dissolved 15 g of sugar in 85 mL of hot water (resulting in 15% sugared hot water). (2) Put three blue mallow flowers (Polish production) into a teapot. (3) Poured the 15% sugared hot water into the teapot and leave it for 3 minutes. (4) Put 3 g of hibiscus calyxes (Taiwanese production) into another teapot. (5) Poured the hot water into the teapot containing hibiscus calyxes and leave it for 3

minutes. (6) Poured 15 mL of the sugared blue mallow tea into a transparent bottle. Then, add 5 mL of the non-sugared hibiscus tea to it little by little (this is important) and leave it for a few minutes. Our experiment proved that a two-colored rainbow could be made with two kinds of herb teas and sugars. The density of the sugared blue mallow tea was higher than that of the non-sugared hibiscus tea, and the former sank below the lower layer. After a few minutes, the two-colored tea settled into a four-colored rainbow tea. The resultant rainbow appeared in the order "blue, purple, colorless, red" from bottom up. Among them, the purple layer was formed by the hibiscus derived H^+. However, the educational impact of the experiment is still under consideration.

[26P1Y-2] Lessons of Human Evolution Using a Human Skull Replica Produced with 3D Printing Technology (*A0320*)

Chieko Uchiyama*+ and Masaharu Takemura

Tokyo Gakugei University and Tokyo University of Science, Japan

ABSTRACT For this study, we produced human skulls (Australopithecus, Homo erectus, Homo sapiens) as 3D teaching materials, using 3D printing technology that is widespread recently. Using the replicas, we conducted lessons for elementary school students in Noda and junior high school students in Tokyo. In the lessons, students tried to compare the structure of human skull replicas, and they thought which replica is the oldest while touching replicas with their hands. We developed and administered questionnaires and tests in order to confirm effect of the lesson with replicas. Pre-tests and post-tests results suggest that this study program incorporating miniature replicas contributed to student recognition that humans have evolved through repeated speciation and extinction.

Secondly, we classified high school students into two groups using different teaching materials: 3D replicas and 2D images sketched in textbooks. Next, the students in both groups learned some skull features such as the jaw shape. Comparison of learner performance when using 3D replicas with that when using 2D images revealed that 3D replicas facilitated the students' visualization of the cranial structure. We anticipate further development of 3D-printed teaching materials to facilitate student learning in various fields.

[26P1Y-3] A Study for Integrating PISA Scientific Literacy Assessment into Inquiry Teaching to Enhance Science Learning Achievement of Elementary School Students (*A0290*)

Huey-Lien Kao[1]*, Hsin-Yu Huang[2], and Ming-Chou Su[3+]

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ABSTRACT For a long time, to cultivate scientific literacy citizens has been a major goal of science education around the world. In addition, many countries advocate the use of inquiry teaching methods to develop students' scientific literacy. Moreover, PISA (The Programme for International Student Assessment) assessment results of "scientific literacy" have become an important measure of a student's academic achievement on science in many countries, and have a very important influence for driven direction of scientific literacy education. Therefore, the purpose of this study was to integrate PISA scientific literacy assessment into inquiry teaching to enhance science learning achievements and the PISA scientific literacy of elementary school fifth-grade students. Actually, the definition of scientific literacy is diverse. Scientific literacy in PISA 2015 is defined by the three competencies to: (1) Explain phenomena scientifically; (2) Evaluate and design scientific enquiry; and (3) Interpret data and evidence scientifically. This study selected five sub-competencies of PISA: (1.1) Recall and apply appropriate scientific knowledge; (1.3) Make and justify appropriate predictions; (2.1) Identify the question explored in a given scientific study; (2.2) Distinguish questions that are possible to investigate scientifically; and (3.2) Analyse and interpret data and draw appropriate conclusions (PISA 2015: DRAFT SCIENCE FRAMEWORK, 2013), as a basis for literacy abilities. As for teaching practices, this study adopted the POEA (Prediction, Observation, Explanation and Application) inquiry teaching method. This study used a quasi-experimental method to fifth-grade students in a total of two classes and 46 subjects in Kaohsiung. The experimental group was implemented by integrating PISA scientific literacy assessment into POEA inquiry pedagogy and by group cooperative learning, whereas the control group was implemented by the textbook teaching process. This study further used pre- and post-test scores on the "two tier test of mater and heat unit" to compare students' science learning outcomes of the experimental and control groups. In addition, this study used scores on the "scientific inquiry learning sheets" to learn if the students of the experimental group had been promoted on the PISA scientific literacy assessment. The results of this study knew that the experimental group did better in the post test of "two tier test of mater and heat unit", relative to the control group, and the difference was statistically significant. In addition, the five sub-competencies of PISA scientific literacy assessment have been enhanced for different learning abilities of the experimental students.

[26P1Y-4] The Effects on Students' Learning Motivation and Reading Literacy in Connecting Picture Books with Nature and Science Technology Curriculum in Elementary Schools (*A0253*)

Shu-Wen Liu[1], Wei-Shan Lin[2], and Ruei-Ping Chang[3]

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ABSTRACT Engagement with picture books has many benefits for children including supporting the development of knowledge acquisition and meaning making skills (Costello & Kolodziej, 2006). Also, children's literature can be a wonderful springboard for classroom learning, motivating students to think scientifically and helping them develop important science-process skills. Besides, the visual images in a science-oriented picture book should help learners get the picture. Casteel and Isom (1994) said that trade books that provide such opportunities are valuable additions to both reading and science programs. Hence, this study was designed to explore the effects on students' learning motivation and reading literacy in nature and science technology curriculum with picture books assistant

of grade 5th and 6th in elementary schools. This experiment is a qualitative research by exploring and observing two picture books with multi-tasking scientific experiments groups. Experiment groups contain two classes and there are around 30 grade 5th and 6th students in each class. We used two picture books in grade 5th class, the two books are "What's That Sound?" and "Sounds All Around" to help students discover that sound is caused by vibrating matter and that sound can make matter vibrate. On the other hand, in 6th class, we used "Now & Ben: The Modern Inventions of Benjamin Franklin" and "Build It: Invent New Structures and Contraptions" to inspire students to use the engineering design process to solve some of their own everyday problems. We were used observation, interview, and video-taping to collect data. In addition, data was analyzed by video-taping analysis and selective verbatim record. We expect to discover the influences of learning motivation and reading literacy in multi-tasking scientific experiments with picture books assistant in the science curriculum. Our results indicated that by using picture books with multi-tasking scientific experiments, students could be positively increase their learning motivation in science curriculum. For example, comparing to students' engagements in traditional science class, students are more concentrating on the class and willing to try and experience variety of scientific activities for learning. In addition, students were able to improving their reading literacy in science curriculum followed by multi-tasking scientific experiments with picture books assistant. Most of students enjoy reading picture books for learning science concepts and increase their motivation for reading. From teachers' point of view, they also feel that using picture books with multi-tasking scientific experiments can effectively to attract students' attention and help students to focus on the classroom. This study confirmed the appropriate teaching strategy to improve students' learning motivation and reading literacy in natural and science technology classes by integrating picture books and multi-tasking scientific experiments in the science classroom. Nature and science technology curriculum can be combined Chinese curriculum to solve the problem of insufficient teaching time. Needed to build a selection guidelines for science picture books in Taiwan so that science teachers can followed when they choosing picture books.

[26P1Y-5] A Case Study of Custom-made Workshops for Informal Ocean Science Educators (*A0026*)

Akiko Tsuzuki*+, Noriko Imamiya, Kazuya Hirai, and Yukiko Mori
Marine Learning Center, Japan

ABSTRACT In Japan, Basic Act on Ocean Policy was enforced in 2007. This act requests to encourage marine education in formal schools and informal settings as well as to develop marine educators in order to improve citizens' ocean literacy. We have collaborated with informal educators and institutions for implementing marine educational activities in various parts of Japan. Through these collaborations, we have found that those educators do not have chances to study basic theories and practices about teaching and learning, and that they cannot help practicing marine education only with their own expertise about ocean sciences. We therefore designed, practiced, and assessed custom-made workshops for informal marine educators, with making use of Communicating Ocean Sciences to Informal Audiences (COSIA). COSIA is a college course to give undergraduate/graduate students the opportunity to explore inquiry-based science pedagogy, developed by Lawrence Hall of Science (LHS), UC Berkeley. We have been working with LHS for disseminating this course in Japan since 2009. Our purpose was to provide informal marine educators with training opportunities to develop their skills to communicate ocean sciences. We set the following aims in holding these workshops: a) to introduce the participants the constructivist teaching and learning, b) to develop their skills to implement their original marine education programs, and c) to make a base for the participants to collaborate each other for the long term. We tried to meet the needs of informal marine educators' professional development through following methods. 1) Designing/ implementing workshops based on the contents of COSIA From March 2012 to Jan 2016, we held six workshops at three regional core informal education institutions. We called for participants widely from various organizations in these regions, and 133 informal educators in total experienced these workshops. Each workshop focused on: a) providing the participants with learning experience of exemplary hands-on learning programs, b) giving lectures on teaching and learning theories behind those hands-on programs, and c) group-works to design marine education programs by applying the learning experience. 2) Assessing each workshop with post questionnaire surveys consisted of four-grade assessment and free description. 3) Follow-up for the participants to implement their own education program. The participants found the learning experience in each workshop useful for their educational practices. These workshops provided them the motivation to collaborate each other in their practices. They however found difficulties to refine and implement educational programs they developed during these workshops. The framework of our two-day workshops seemed effective for providing informal marine educators with the constructivist view of teaching and learning. These informal educators needed continuous supports for implementing their practices through the regional collaboration with other educators.

[26P1Y-6] The Analysis of Science Communication in Dinosaur Exhibit Media (*A0314*)

Jiyeon Yu*, Gu-Reum Park, and Young-Shin Park+
Chosun University, Korea

ABSTRACT For public understandings of science (PUS) by citizen, the role of science education is critical in informal education as well as formal education. Science museum, the most representing place of informal education places, is where citizen can achieve their own educational goals by communicating with exhibits and docents who interprets exhibits. In science museum, basically science is communicated through the displayed exhibit panels, but to supplement this, the various exhibit media have been utilized. In this study, the research team developed the 'practical exhibit media analyzing frame' which can investigate what type of the exhibit media is used at the science museum in Korea, and which science communication is utilized and reinforced depending on the various kinds of exhibit media. Science communication is

defined as the tool to meet the goal of science education, scientific literacy. Science communication consists of 6 different components (concept, interest, nature of science, opinion, awareness and enjoyment). Four natural history museums including dinosaur exhibits from 4 different countries (Korea, Taiwan, UK, and USA) were selected for this study. The research team collected the data from dinosaur exhibits to see what kinds of media there were and how they delivered science communication. The results were as follows; (1) The most dominating components of science communication were 'interest' as well as 'concept' in all countries. (2) Most exhibit media were used to attract visitors (interest mainly) but they were not enough to communicate science as a type of engaging model, which means that other components (opinion, awareness, nature of science) were very limited to be included in dinosaur exhibit media. (3) More engaging models of exhibit media were found in museums in UK and USA. (4) More combined media presentation rather than the individual exhibit media one was reflecting science communication more effectively. The following implication were made; The exhibit media must be designed to hold all components of science communication as the presentation of engaging model. To meet this goal, it is critical to train or equip exhibit planner/developer with full understandings about science communication as the engaging model.

[26P1Y-7] Analysis Ability to Write Physics Laboratory Reports of Undergraduate Students (*A0370*)

Yeo Won Yoon*, Sang Tae Park+, and Hyo Jun Seok
Kongju National University, Korea

ABSTRACT This study was analyzed about ability to write physics laboratory reports by using analysis frame for undergraduate physics laboratory reports in collecting, processing, and analyzing data Shinkwangmoon′ s development (2011). Selected 20 people among students in the third grade and taking advanced physics experiments had been conducted in total of 60 students for three years. A review were conducted by using frame. After analyzing the laboratory reports, evaluation items in the data collection showed a relatively high score but some students did subject to report without repeated measurements. For data processing, tables and graphs category showed a high score but most of the students didn′ t know about uncertainty concept. For data analysis, some students didn′ t interpret tables and graphs, the students did not seem to quantitatively analyze the error in case of error. They felt difficult to write physics laboratory reports although the experimental class wasn′ t the first time to them. Especially, it has been found that data analysis capability have been fallen a lot. To find the reason for this, more detailed researches will be to analyze for such as a curriculum, but the students experimental class will need to teach the physics concept about experiment as well as to teach basic concept of data collecting, processing, and analyzing. [Draft]

[26P1Y-9] Cultivating Future Global Leaders for the Revitalization of Northern Japan (*A0246*)

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Iowa State University of Science and Technology, USA and University of Aizu, Japan

ABSTRACT This poster presentation describes a curriculum development project at the University of Aizu in Fukushima Prefecture, Japan. Following the triple disaster of earthquake, tsunami, and nuclear event of 2011 in northern Japan (Tohoku), the Fukushima government embarked on an ambitious, large-scale recovery strategy to revitalize the prefecture. A key educational goal is to inspire and educate students for the development of global citizens capable of leading the ongoing revitalization effort. The University of Aizu offers undergraduate and graduate degree programs in computer science only. Our global leader project employed a community of practice approach in which university teachers and graduate students guided small groups of undergraduate students to reflect on and make sense of regional conditions and strategies for the revitalization. Our students identified specific problems arising from the disaster such as communication, shelter, and food supplies. They also considered short-term solutions and possible technical innovations that might better address the problems. From this starting point, the students created short documentaries. Some groups interviewed international staff and students about disasters in their home countries to provide a comparison. Using this information, each group narrated and subtitled their video recording. Students were encouraged to research more than just the technical aspects of the disaster. They were also asked to include the impressions and feelings of the interviewees about their relationship to nature. The resulting video productions were evaluated using rubrics focusing on production, English language use, research method, critical thinking, awareness of social issues, and other variables. Resulting improvements in our method will be discussed. Key institutional goals at the University of Aizu include increasing student interest in studying computer science through active learning, while also promoting innovation. We will describe the implementation effort from the perspectives of teacher development, curriculum development, social organization, and technical requirements

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[26P1Y-10] An Approach to Developing Electronic Lab-book for Chemistry Experiment (*A0516*)

Akira Ikuo*+, Yusuke Yoshinaga, and Haruo Ogawa
Department of Chemistry, Tokyo Gakugei University, Japan

ABSTRACT We are developing an electronic lab-book for a basic chemistry-experiment for university students in which reaction mechanisms are shown by computer graphics (CG). The CG of chemical reaction was made based on empirical molecular orbital calculations (SIGRESS, MOPAC/PM5). The CG included following reactions; 1) formation of di-atomic molecule by collision of two atoms such as hydrogen iodide, 2) hydroxylation of methyl chloride, formation of 1-bromobutane and 2-butyl alcohol as a model of Walden's inversion where drastic change in structure takes place, 3) esterification of acetic acid and ethanol as an example of more complex reaction. The CG can simultaneously demonstrate the nature of the reaction such as structural change by the space-filling and the ball-and-stick models in addition to providing an image of energy change by the reaction profile. The electronic lab-book also displays pictures of apparatus and flow-charts of small-scale experiments. Therefore students are able to conduct experiments smoothly and safely while

studying dynamical reaction mechanism shown by the CG. The electronic lab-book in tablet could be used to integrate the observable level experiment and the molecular world.

[26P1Y-11] A Comparative Study on Biology Textbooks for Upper Secondary Schools between Japan and England: Focusing on the Context of Everyday Life and Society (*A0295*)

Takuma Edamura*+ and Tetsuo Isozaki
Hiroshima University, Japan

ABSTRACT The results of PISA (2006) and TIMSS (2007, 2011) have described that Japanese students have shown low interests and low self-efficiency for learning science compared with the international average. Ministry of Education (2009) stated that: "From the view of opportunity for students to realize meaning and self-efficiency and improve interests to learn science, science education will improve to enrich contents which focus on the context of everyday life and society" in the Course of Study for upper secondary school science. On the other hand, in England, there is a biology curriculum (ages 16-18) which is called "Salters-Nuffield Advanced Biology (SNAB)" employs the context-based approach and enhances the context of everyday life and society. With these situations of science education in both countries, we formulated the following research question: What differences are represented in biology textbooks at an upper secondary school level between "SNAB" and "Advanced Biology"? To answer this research question, we compared them with focusing on how the context of everyday life and society is treated in the unit of "Genes". As a result, we found out the following difference between them: three "Advanced Biology" textbooks focus on teaching biological concepts such as structure of the DNA, and the context is used for applying what they learn in everyday life and society. By contrast, "SNAB" textbook starts the unit with the context of everyday life and society such as genetic disorders. Through the "Genes" unit, students can learn biological concepts that needed to understand the real-life context (University of York Science Education Group, 2015).

[26P1Y-12] Synthesis of Triarylmethane Dye Molecules utilizing Boric Silica Gel (*A0147*)

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ABSTRACT The synthesis of triarylmethane dye molecules has been an important subject in the world of organic chemistry for many years. In this experiment, various dyes including rhodamine B (red dye), fluorescein (green dye, fluorescent material), and phenolphthalein (acidity-basicity indicator) can be synthesized with substituted phenols and phthalic anhydride as ingredients, using Friedel-Crafts type reactions. Synthesizing dyes that clearly change color is used in high school experiments to teach organic chemistry thanks because of its visual impact. The synthesis of azo dyes has been experienced by many high school students. However, experiments synthesizing triarylmethane dyes involve the use of concentrated sulfuric acid as a catalyst, and therefore tend to be avoided. Therefore, the objective of this study was to develop a reaction for synthesizing a dye that is safe and has low-impact on the environment by studying the reaction for synthesizing triarylmethane dyes using boric silica gel as a solid acid catalyst. 0.20 mmol (30 mg) of phthalic anhydride and 0.80 mmol (132 mg) of 3-(Diethylamino)phenol was weighed out into a test tube, and 50 mg of NaHSO4 supported on boric silica gel is added and mixed well. By heating this for 20 minutes at 160 ℃ it was possible to get a 61% yield of rhodamine B. In the same manner, when 0.80 mmol (88 mg) of resorcinol was used, it was possible to produce a 60% yield of fluorescein, and the recovery of both was a simple matter. On the other hand, the synthesis of phenolphthalein is difficult because its raw material is phenol, which has a melting point of 41 ℃ and a boiling point of 182 ℃, which leads to vaporized phenol condensing on the sides of the test tube, and thus reducing the net amount of phenol. Therefore, slender test tube was placed in a test tube for reacting, thus narrowing the surface area and solving the problem. 0.20 mmol (30 mg) of phthalic anhydride, 1.00 mmol (94 mg) of phenol and 100 mg of titanium sulfate supported on silica gel was introduced and mixed well. By heating for 20 minutes at 160 ℃ it was possible to obtain a 38% yield of phenolphthalein. Along with introducing innovations in equipment, we will also report on the synthesis of dyes and summarize on teaching programs including its use.

[26P1Y-13] Developing Physics Learning Material using Scientific Approach for New Indonesian Curriculum (*A0335*)

Elwinda Dwi Pratiwi[1]*+, Kaharuddin Arafah[2], and Jinwoong Song[1]
1. Seoul National University, Korea and 2. State University of Makassar, Indonesia

ABSTRACT Curriculum 2013 in Indonesia, which has been applied since 2014, suggests 'Scientific Approach.' The scientific approach in Curriculum 2013 emphasizes personal experience through the processes of observing, of questioning, of associating, of experimenting (observation-based learning), and of networking through collaborative learning. In this study, we aim to develop physics learning materials based on those five steps of scientific approach and to evaluate the effects in terms of students' achievement and the quality of learning process. We developed by using 3D (define, design, develop) Model that was a modification of 4D Model by Thiagarajan (1974). Firstly, in the development stage, we defined instructional requirement through observation and analytical processes of teachers, of learners, of tasks, of concepts, and of objectives in learning. Then, we designed a prototype instructional material based on the scientific approach. Focusing on the 'Optics' chapter, four sets of the learning material (i.e., lesson plan, student's book, student's worksheet, and authentic assessment) were developed and administered to the experimental class. Those products concern with basic competence in analyzing how the optical instruments work dealing with reflection and refraction concepts and it is devoted to exercise, projects, and discussion. The materials were revised after being validated by four experts in science education regarding their contents and items validities. Secondly, we analyzed the effectiveness of learning materials in both quantitative and qualitative ways. It was tried out in an experimental group of 35 students from first grade at senior high school. The data were gathered using questionnaire, observation sheet, and students' achievement. The results show that there was

the difference in the average of students' performance between experimental class and control class. The average score of the post-test was the experimental class with 71.8 and control class 51.4. Also, most students gave positive responses to the materials and learning process and students' activities met ideal range. However, some tasks presented difficulty to some students who lack a deeper knowledge of physics. Findings supported that these developed materials will be helpful in practical classes for all student. The actual implementation of these materials to students would refer to the final revision based on the particular points.

[26P1Y-15] The Factor of Science-phobia: Test of a Causal Model of Likability of Science (*A0220*)

Kana Suematsu
The University of Tokyo, Japan

ABSTRACT The results of PISA 2006 showed that Japanese students take a low interest in science. This has been one of the problems of the Japanese science education, known as a science-phobia from the late 1980s. It has been previously reported that the factor of science-phobia was insufficient experience in nature, negative feeling toward math, and so on. However, there has been little suggestion about the relationship between such factors and a likability of science. The purpose of this study is to show the causal relationship between likability of science and the factor of science-phobia. This study investigated about likability and interest in science when respondents were in their elementary school, junior high school, and high school, as well as the experience in nature, science and technology and interest about nature, science and technology. 1,004 students at 11 universities located in the Tokyo metropolitan area completed the questionnaire form. The causal model about the factor of science-phobia was constructed using covariance structure analysis. As a result, there was a significant direct effect of the experience in nature on likability of biology and geoscience, and the experience in science and technology on likability of physics and chemistry.

[26P1Y-16] Analyzing the Behavioral Differences between Successful and Unsuccessful Learners in Evaluating Scientific Explanations (*A0261*)

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Institute of Education, National Chiao Tung University, Taiwan

ABSTRACT Scientific explanation evaluation is an important scientific literacy. Citizens should possess this ability to making judgments on quality of scientific explanations in order to participate in civil decisions (OECD, 2013). Abundant evidence has adduced that self-regulated learning (SRL) plays a crucial role when students learning and accomplishing complex task like inquiry (e.g., Zhang, Hsu, Wang, & Ho, 2015). However, empirical study that explores influence and process of SRL on scientific explanation evaluation is lacking. To address this gap, this study aims to address the following research questions: What are the differences between successful and unsuccessful scientific explanation evaluators regarding their use of SRL strategies? Whether they exhibit different SRL behavioral patterns? A total of 16 undergraduates joined this study. The task of scientific explanation evaluations involves four phases: (1) reading the context and a research question of a simulated scientific inquiry, (2) analyzing a set of second-hand data, and (3 and 4) making judgments on quality of two given scientific explanations based on information in phases (1) and (2). The four phases were displayed in sequence, and the participants were asked to think-aloud while performing the task. The think-aloud protocols were coded for students' SRL strategies including: reading (RE), analyzing (AN), inferring (IN), monitoring (MO), and evaluating (EV). The students were grouped as successful (n=6, M=4.17) and unsuccessful evaluators (n=10, M=1.60) according to their scores on scientific explanation evaluations (W=55, p<.001). Frequencies of SRL strategies were computed and SRL behavioral patterns were analyzed using a sequential analysis technique. Data for the two groups were then compared and discussed. Our results show that both the successful and unsuccessful evaluators frequently used reading (successful: M=9.17; unsuccessful: M=9.00) and monitoring strategies (successful: M=6.17; unsuccessful: M=8.20), followed by evaluating (successful: M=2.83; unsuccessful: M=3.30) and analyzing (successful: M=2.67; unsuccessful: M=1.00); except for the successful evaluators (M=5.17) nearly significantly demonstrated more inferring (W=69.00, p=.08) strategies than the unsuccessful evaluators (M=2.80). Differences in SRL behavioral patterns were also observed. The pattern of successful evaluators consists of significant sequential links on RE→AN, AN→MO, and IN→EV, whereas that of the unsuccessful evaluators includes links on RE↔AN, and RE↔MO. The results reveal that both successful and unsuccessful evaluators read and analyzed the context carefully. The differences lie in that (1) the successful evaluators monitored their reading and analyzing process, whereas the unsuccessful evaluators mainly monitor their reading process. In addition, (2) the successful evaluators used more inferring strategies and evaluated their results of inference, whereas the unsuccessful evaluators used less inferring strategies and the evaluating strategies did not support other strategies. The present study indicates that higher-order strategies like inferring and analyzing strategies have played a crucial role, and these cognitive strategies need to be incorporated with metacognitive strategies like monitoring and evaluating to yield better performance on scientific explanation evaluation. Discussions and implications will be reported in the full paper.

[26P1Y-18] Fifth Graders' Multimodal Representations of Birds in Expository Writing (*A0066*)

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ABSTRACT Literature suggests that instructional models should provide active learning experiences, involve learners in inquiry activities, and facilitate them to construct science knowledge through moving among different modes of engagement and representation. Furthermore, a series of well-designed writing activities embedded in active inquiry can enhance students' learning of science and about science. In this curricular action research, thirty-six fifth graders participated in an after-school science program. An invited expert and an experienced lead teacher collaborated to plan and enact the program. The lessons included learning

activities such as Birds around Me, Observing Birds, Searching Information about Birds, Reading about Birds, and Taking Actions about Birds. The students kept notes during the lessons and wrote expositions with multimodal representations to communicate to their family members about their multiple modes of involvements and their conceptual understandings about birds at the end of each period. The constant comparative method was applied to analyze students' expository writing in terms of the students' procedural understanding and conceptual understandings about birds, as well as their environmental awareness. The analysis of student artifacts revealed that, at the beginning, the fifth graders frequently document observable feeding and migrating behaviors or characteristics of birds, moreover, they were highly motivated to engage in operating binoculars or monocular telescopes. However, they were in needs of guidance to integrate their conceptual and procedural understandings for developing an observation plan and building explanations. The researcher and the invited expert modified the lessons and embedded more practical works. They utilized a design and simulation activity of the airflow and bird flight to assist the students to deliberate upon observation plans in accordance with birds' various behaviors. In addition, they prompted the students to keep a long-term observation journal of the birds in the campus in order to encourage the students to search and read necessary information. This modified program was successful in increasing the students' multimodal representation ability. The students also demonstrated that they are capable of making appropriate judgments and taking righteous actions.

[26P1Y-19] High School Students' Strategies to Learning Biology with Relationships to Epistemic Views of Biology and Conceptions of Learning Biology: A Study of Structural Equation Modeling Analysis in Taiwan (*A0071*)

Kuan-Ming Shen[1*+], Min-Hsien Lee[1], Chin-Chung Tsai[2], and Chung-Yuan Hsu[3]

1. Institute of Education, National Sun Yat-sen University, 2. National Taiwan University of Science and Technology, and 3. National PingTung University of Science and Technology, Taiwan

ABSTRACT In the area of science education research, it is important to look into how students think about biology knowledge and learning biology. Several studies have attempted to investigate students' epistemic views, conceptions of learning, and learning strategies as a result of being attributed to students' academic performance. Moreover, biology is regarded as a particularly difficult subject to learn in the science domains by reason of the breadth and complexity of biology knowledge. Referring to the research methods and findings in the field of science education, it is now timely to explore students' strategies to learning biology based on their epistemic views of biology knowledge and conceptions of learning biology. Accordingly, this study aimed to examine the relationships among high school students' learning strategies, epistemic views, and conceptions of learning of biology through a structural equation modelling technique. To this end, a total of 247 11th and 12th graders (168 males) participating in this study completed three questionnaires, the Epistemic Views of Biology (EVB), the Conceptions of Learning Biology (COLB), and the Strategies to Learning Biology (SLB), respectively. The factor analysis results indicated that the two COLB factors as "Increasing one's Knowledge" and "Understanding" were grouped into one factor as "Increasing one's Knowledge and Understanding" which may reflect the specific feature of biology learning in Taiwan. The Structural Equational modelling analysis results indicated that students' epistemic views of biology made a significant contribution to their conceptions of learning biology, which were consequently correlated with their strategies to learning biology. More specially, students with more sophisticated epistemic views of the "Justification" tended to possess higher-level conceptions of learning biology, such as "Increase of Knowledge and Understanding", and "Seeing in a new way", and hence were prone to conduct the deep strategy to learning biology. Moreover, students with less advanced epistemic views of the "Certainty" tended to have lower-level conceptions of learning biology, such as "Testing," and were likely to adopt surface strategy to learning biology. This study identified the structural relationships among students' learning strategies, epistemic views, and conceptions of learning in biology. Based on the results, practical implications for biology education and suggestions for future research are discussed.

[26P1Y-21] Analysis of Attitude and Knowledge State about Physics by Physics Course Selection (*A0094*)

Kwangkyu Choi

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ABSTRACT Many students are reluctant to study of natural sciences or engineering. In especially, avoid physics. The discussion on the analysis of the specific cause, and solution is being progress. For example, discussion of the social and economic status of physicists, the question of the cross support in the college entrance examination, such as the social climate a priority for economic stability and the value is indicated. However, rather than these discussions, it is necessary to analyze the causes of admission from students. The percentage of students trying to choose the applied physics degree? If students do try to select a physics why choose? What are you do not select a physical reason? In previous studies, it was emphasized that creating a science-related attitudes make love science as important as the positive goals of science education. For this study of physics student's behaviour towards any differences between groups of students report that the hierarchy of knowledge by analyzing the fundamental reason was trying to detect. Wood (1975) has defined as a systematic arrangement between an ordered sequence allows, among them to study questions or challenges the hierarchy, the more successful learning tasks or items of high level. Olsen (1968) has defined Curriculum coursework or special concepts related to some coursework in the hierarchies of overall sequence or partial sequence. Organize and knowledge to the concept of logical order from empirical data to be determined by the structure. Rogers (1977) saw a collection of items in a systematic sequence star or learning tasks that can include a variety of the hierarchy. Druva(1985) has defined the order and systematic gathering of some features in order to successfully perform a higher-level function, indispensable. In this sense, the theory of Piaget is a hierarchy tinged with psychological

sequence star stipulated in cognitive developmental psychology, theories of Gagne's analysis, a professor of challenges that must be learned, not that interested in whether the state or structure of knowledge of learners - learning sequence star or a logical hierarchical sequence star, and saw a hierarchy of empirical sequence. To the learner reaches the full on any given objective, positive transition as possible between by the organization allows the validity of the hierarchical relationship of the higher-level learning elements needed to study the function of or learning units from the function of the lower-level learning elements the overall rank is important to find a relevance that can cause. So I think that after analyzing the state of knowledge students utilize the knowledge hierarchy If you use them to learn to be able to change the students' attitudes toward physics. [Draft]

[26P1Y-22] The Anthropologram of School Subject Pictured by Teachers (*A0292*)

Ryoei Yoshioka

National Institute for Educational Policy Research, Japan

ABSTRACT This study is a Japan and Germany comparative study for teachers of high school stage. The purpose of the research is to extract the impression of the school subject from the teachers in charge of the subject and to compare the image of subjects. The purpose of the school education is the education for the whole person. But the education is divided into the subject has been carried out in the school education. Therefore, each only one subject is not able to achieve its final purpose. In other words, it is believed that the whole person education has been carried out as a whole the combined each subject. We asked in the questionnaire to teachers in charge, whether her/his own subject is responsible for what. We could get more than hundred teachers' answer in each country. We represented the result in anthropologram and discussed them. The anthropologram is look like a radar chart. There are 28 axes which means each human characteristic. As a result, each subject has a unique profile and there is a distance in each other. And the subject profiles are not same in Japan and in Germany.

[26P1Y-23] Analysis on the Teachers' Recognition of the Supporting System for Gifted Education in Korea (*A0389*)

Jeong-Im Woo*+ and Kyung-Hee Hong

Wonmook High School and Seoul Metropolitan Office of Education, Korea

ABSTRACT Gifted Education was regularized in Korea from 2002, when the ordinance of Act on the Promotion of Specific Education for Brilliant Children was executed. Afterwards, regardless of any quantitative and qualitative improvements of the Korean Gifted Education System made, problems concerning students' higher dependence on private education to be selected for Gifted Education, teachers' burden on managing tasks, curricula, and etc still exist. This study aims to diagnose the current supporting system for Gifted Education in Seoul Metropolitan Office of Education. We investigated the difficulties in managing gifted education, the urgent improvement requirements, the difficulties in the identification process and so on. From the questionnaires by 238 teachers who are in charge of Gifted Education in 2016, 83.2% of the teachers positively answered on the necessity of Gifted Education, and 69.7% of the teachers answered that it is necessary to expand the isolated gifted students. 78.6% of the teachers have experiences on managing gifted education, and 60.6% of the teachers received 60-hour-traning course for the gifted education. There were negative reactions with managing tasks. 18.1% of teachers worked involuntarily and 50.0% of teachers did not have positive experiences in managing tasks. 42.0% of teachers didn't want to be in charge of gifted education for the coming year. The difficulties experienced by the teachers lied in excessive administrative tasks by 51.7%, and in after-school working including night and weekend by 28.9%. Respectively 25.6% of teachers expressed urgent needs to simplify tasks and ask for incentives of managing works. From these results, the management tasks for Gifted Education require practical support. The reduction of administrative tasks and the benefits with extra pay, promotion chance, school transference, etc. should be provided by the Education Office. Gifted Education Databases, provided by the government in 2015 worked efficiently to identify gifted students (63.4% of the teachers) and to reduce identification processing tasks (65.5% of the teachers). It should be helpful to reduce the dependence on private education.

[26P1Y-24] A Comparative Study on the History of Science between Chinese and Japanese Physics Teachers (*A0259*)

Yunyi Zhang*+ and Tetsuo Isozaki

Hiroshima University, Japan

ABSTRACT A lot of literature suggests the important of the history of science in teaching science for understanding science itself (e.g., Lederman, 1992; Seroglou, 2001) In China, Curriculum Standard Senior High School (test) that launched out in 2003 also emphasizes learning the history of science as an essential part of learning science. Not only learning of the history of science is mentioned on the objectives, but also requested in the part of content standard. By contrast, learning the history of science is not strictly taken as an objective in the Course of Study for upper secondary school in Japan. To investigate how those differences in curriculums and also textbooks influence science teaching, authors are planning a comparative study to figure out the following research question: What are the differences on prospective of the history of science between Chinese and Japanese physics teachers? In this research, we are conducting the research by questionnaire and interviews both in China and Japan. We choose eight experienced teachers, four of them are from China and the others are from Japan, to participate in the level of the questionnaire. We chose eight upper secondary school teachers, four of them are from China and the other four teachers are from Japan, with more than 10 years teaching experience in physics education with master degrees on science education or physics' education. Then we specify four teachers to compete the interviews for deeper analysis. We prepare the questionnaire among physics teachers both in the two countries before execute interviews. This questionnaire is conducted as open-ended form, for getting the response spontaneously. It includes nine questions that categorized into four sections, which are education background of the history of science, teachers' cognition of the history of science, usage of the history of science in

teaching science and recommendation for using the history of science in teaching science. As a result of the pilot research, it shows that a physics teacher in Japan actually using the history of science in each unit on physics textbook in order to encourage students' interest in learning science, even though the Course of Study does not require in the objectives. Meantime, all of three Chinese physics teachers showed their interest and action on using history of science in teaching science, such as distributing relevant materials and letting students do a presentation on a historical topic. Physics teachers as this research's respondents do have the cognition of utilizing the history of science in teaching science. With analyzing relevant literatures on teaching the history of science, we can briefly conclude that the knowledge of the history of science can enable student to take an active interest in science, and also develop their scientific literacy, which reflected the contribution of learning the history of science in physics education.

[26P1Y-26] A Study of Teaching Reading in Science Classroom (*A0029*)

Jing-Ru Wang
National Pingtung University, Taiwan

ABSTRACT This study explored the professional change for a science teacher in the instruction of reading comprehension on science text. The participants included a science teacher and her fifth-grade and sixth-grade students of an elementary school in southern Taiwan. The first classroom demonstration with fifth grader at 2014, she taught "The Movement of Stars," in which she wants her students to develop understanding of the concept "The earth's motion around the sun brings different stars into view as the season progress." through reading the text for two sessions. In her second classroom demonstration with six graders in 2015, Dai taught "Black Holes" in which she wanted students to know the tentativeness of science knowledge through reading the information about the development of knowledge about black holes for two sessions. The data were collected through the ways of classroom observation, interviews with the case teacher and her students. To evaluate the teacher's professional change, I also collected the teacher's journals, teaching plans and mind maps about teaching science reading. I found that the teacher's pedagogical content knowledge about reading science text was context-dependent and developed gradually. The science texts and reading lessons were embedded in the lessen unit designed by the case teacher. The teacher's knowledge about teaching science influenced her teaching practices through self-reflection and self-awareness in actions. The factors causing teacher's professional change included the students' assignment; debrief discussions among school teachers and university professor, and teacher's self-reflection and awareness.

[26P1Y-27] Development and Application of a Three-Tier Diagnostic Instrument to Assess Students' Understanding about Matter Science (*A0363*)

King-Dow Su*+
Department of Hospitality Management, De Lin Institute of Technology, Taiwan

ABSTRACT This study focused on the development and application of a three-tier diagnostic instrument (TTDI) for exploring students' the strength of conceptual understanding of the matter science in chemistry. This paper presents results based on the responses of 166 university students who had taken chemistry courses to the particulate nature of the matter (PNM), and to assess possible types of misconception. With respect to observations in the TTDI, the mean difficulty index of students' response was .54, the mean discrimination index was .37, and reliabilities of the Cronbach's α were .680, .774, and .890 for the only first tiers, both two tiers, and all three tiers respectively. All results demonstrated that students' mean answering rates of three-tiers to be 26.51%, lack of knowledge understanding 46.38%, and their self-assessments from cognitive domains of overconfidence 48.19%. All results demonstrated that most students lacked chemistry knowledge understanding, with overconfidence in cognitive domains, and we identified students' 2 misconceptions from the total 13 test items. We developed two test items of new misconceptions in detail for the three-tier diagnostic instrument in this study. A short but sincere thank must also be given to the patronage of Ministry of Science Technology in Taiwan, R.O.C. in Taiwan (under Grant No. MOST 104-2511-S-237-001). Without their help, this study could not have been completed in present form.

[26P1Y-28] Developing an Instrument for Assessing Senior Elementary Students' Understanding on Microalgae Biomass Energy (*A0366*)

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ABSTRACT Microalgae is potential in reducing the carbon dioxide and in transforming as biomass energy, thus it attracts many scientific studies nowadays. This study is to develop an "Assessment Instrument of Microalgae Biomass Energy (AIMBE)" to assess understanding of senior elementary students on microalgae biomass energy technology. Literatures analysis was used to reach four dimensions of major concepts of this theme. The four dimensions are: "(1) Knowing—types and characteristics", "(2) Breeding—waste reduction and reuse", "(3) Processing—collection and extraction", "(4) Appling—products and applications". The research group met weekly to discuss the design and development of assessment instrument content. Content validation was done by three specialists in microalgae. A pilot test was then performed. Of which, 64 were male and 51 were female. The Cronbach α coefficient of 0.82 represented a good reliability. The 30 questions instrument entails 7 questions on "(1) Knowing", 10 questions on "(2) Breeding", 7 questions on "(3) Processing" and 6 questions on "(4) Appling". Data was analyzed by independent t-test to examine the difference in understanding between male and female students. The percentage of correct answers on each category was analyzed by ANOVA to understand the difference in performance by students on these four categories. Results of this study are: 1. The correct answer percentages of four dimensions are: "(1) Knowing (71%)","(2) Breeding (60%)", "(3) Processing(43%)", and "(4) Appling (33%)". 2. Results of t test indicated, there was no significant difference between male and female students on the scores of assessment instrument regarding

"microalgae biomass energy and waste water carbon sequestration reuse". This meant gender has no part in the understanding of microalgae biomass energy. 3. One-way ANOVA results showed significant difference among students' concept on these four dimensions. It was later found by using Post Hoc tests that students' performance in "(1) Knowing" and "(2) Breeding" significantly outperform "(3) Processing" and "(4) Appling". This meant senior grade elementary students are less knowledgeable on "(3) Processing" and "(4) Appling". This could be caused by a lack of elementary school curriculum on these two dimensions, so more learning opportunities relating to these two dimensions might need to be provided to elementary students. This assessment instrument is reliable for assessing the understanding of senior elementary students on microalgae biomass energy technology. The results also show senior elementary students' weaknesses on "(3) Processing" and "(4) Appling". This information could be used as reference when develop future teaching materials and instructional design.

[26P1Y-29] Mediating Factors of Urban Effect on Science and Mathematics Achievement of Taiwaness Grade Eight Students (*A0392*)

Che-Di Lee
National Taiwan Normal University, Taiwan

ABSTRACT This study aimed to build an evidence base for Taiwan's educational policy to minimize rural-urban educational gap and focused on identifying factors mediating the urban effect on Taiwaness grade eight students' science and mathematics achievement. Data for analysis were collected from 150 schools, 152 classes, and 5042 students participating in Trends in International Mathematics and Science Study 2011 (TIMSS 2011). Multiple regression and Oaxaca-Blinder decomposition method were used to analyze the contribution of factors on students' achievement. In this study, urban was defined as the region with population more than 500,000. For science achievement, the urban and non-urban difference was 35.3 points. At the individual level, home educational resource explained 9.0 points (26%), students' educational expectation explained 8.0 points (23%), and students' confidence in learning science explained 3.7 points (11%). At the class level, class average of students' educational expectation explained 8.1 points (23%). The overall explained gap by the above variables was 28.9 points (82%) and the unexplained part was statistically insignificant. For mathematics achievement, the urban and non-urban difference was 48.3 points. At the individual level, home educational resource explained 8.7 points (18%), students' educational expectation explained 8.2 points (17%), and students' confidence in learning science explained 5.5 points (11%). At the class level, class average of students' educational expectation explained 14.9 points (31%) and teacher's years of teaching experience explained 2.8 points (6%). The overall explained gap by the above variables was 40.1 points (83%) and the unexplained part was statistically insignificant. The results firstly indicate that students with the same background including the same level of educational expectation would have higher achievement if they were in classes with higher calss average of educational expectaion. This mediating effect could explain most of the urban and non urban achievement difference at the class level. Based on this study, raising class climate of educational expectation is the first priority as considering related educational policy. Secondly, teachers' years of teaching experience is the second priority and its importance is depending on the subject.

Poster 2X (27th, 11:30-12:50)

[27P2X-1] Expectation on the Usage of ICT Knowledge in Science Activity of Scientifically Gifted through Software Education (*A0521*)

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Ewha Womans University, Korea

ABSTRACT The Ministry of Education of Korea announced an education policy which would help students to gain interests, enhance understanding upon science and technology, and develop integrated thinking ability and problem solving skills, in 2015. Because the upcoming future will be a software-centric society, people with talents should solve everyday problems by familiarizing with computational thinking to fuse creative ideas with science and technology. Software (SW) education is highlighted in the 2015 Revised Korean National Curriculum and Guide for Operating SW education. For example, learning algorithms by using SW and activities using sensors/output control can be an effective method for scientific inquiry. This method can also be applied in improving computational thinking of students. In this study, we designed lessons to solve every-day scientific problems using Educational Programming Language (EPL) SW and physical computing materials and applied them. This research was performed of scientifically gifted classes that consist of 47 students who are 5th and 6th grade. We taught the students 3D modelling using '123Design' software of AUTODESK. The students can make any models and printing out the object in 3 Dimensions. These science classes will progress by 'scratch' and physical computing (called 'bitBricks') and will survey student's expectation on the usage of ICT (Information & Communication Technology) knowledge in science activity before and after the classes. The 'bitBricks' is composed of input and output modules. The input modules are sensors and the output modules are motors and LEDs. We can assemble like a LEGO bricks with sensors, motors and LEDs, and we can control the bitBricks using Scratch Programming Language. We also conducted a survey on student's attitude toward learning science after the SW class. We distributed an activity sheet to each student. The sheet has 4 sections and each section helps to observe and analyze how the students develop their learning skills and scientific ability throughout the lesson: (1) What software they are able to use and how fluent using that software. (2) What they would like to do in the future by learning SW and ICT. (3) How learning SW and ICT would help study science. (4) Design a project using SW and ICT related to science activities. Results showed that students find engineering and technology contribute greatly to science development. Therefore, it is expectable that they are highly looking forward to learning and utilizing SW.

[27P2X-2] Effects of Program for High School Student to Facilitate Developing Research Questions in Research Project Class (*A0475*)

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ABSTRACT 'Research Project' is a subject specializing in science research. This was intended to make high school students experience authentic scientific procedures. Students are able to experience the research process of finding a certain scientific topic by investigation, discussion, as well as planning experiments and collecting data. The final step in the process is to write a report based upon the information they collected. They can improve their science inquiry abilities by following the steps of this research process. This Research Project class is effective to develop learner's achievement and motivation, as well as problem-solving ability by having students actively participate. In the first process of research, students begin their research by developing questions. Finding valuable scientific research questions is the very start of the science research and its importance has been emphasized by preceding reports. Previous studies have shown that students experience difficulties leading their own research especially when making research questions. It is very important to provide a systematic teaching program which allows students to develop research questions and how to develop their research designs based on their research questions. In this study we developed a science inquiry teaching/learning model emphasizing developing research questions. This will provide the students with the opportunity to learn the scientific process of developing research questions. We provided 5 steps and applied strategies to each step to facilitate developing research questions. These steps include 'Exploration', 'Literature research and data collection', 'Modification and extension', 'Sharing and evaluation', and 'Final selection and making research plan'. We applied the science education program based on this teaching/learning model to students for one semester. Thirteen high school second grade students attended this class voluntarily where they participated as teams. Classes were given 3 hours every week. Before starting to develop research questions, students were taught through several experiments about research itself and making a hypothesis. Data from 5 weeks of classes was collected. We collected students' activity papers and analyzed the 2 following factors: (1) The type of research question, (2) The level of research question. We also analyzed their final research plans as references. In conclusion we could see how their research questions were developed and specified in each step. Finally, we could provide information about the teaching/learning strategy that helps students to develop research questions and research designs.

[27P2X-3] Analysis of Effects on the Competencies and Understanding about SSI through Pre-service Teachers' Experiences of Producing 'SSI Video Contents' (*A0591*)

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ABSTRACT Promoting scientific literacy, one of many objectives for science education, includes the ability to solve socio-scientific issues(flower, zeidler, sadler, 2009). Thus, the academic community of science education has begun to care about the SSI instruction that helps students to understand and reason various perspectives on socio-scientific issues of modern society (Wee&Lim, 2013). Recent papers on SSI said that the educational effects of introducing SSI are very diverse and positive. It has been reported to be very successful at enhancing students' scientific literacy and deepening their scientific knowledge even in terms of affective aspects(Dolan, 2009; Zeidler, 2005; Wee&Lim, 2013). However, the research of Lee and Witz(2009) shows that the teachers in field and pre-service teachers have difficulties in applying SSI in their classes for various reasons although they are aware of its importance. In particular pre-service teachers have been in the positions of learners for a long time, there is a limit to think of others' point of view, reconstruct the contents, and finally deliver the result to students (Frederik et al., 1999). The classroom experience as a pre-service teacher has critical impact on developing professional teaching ability. However, the teacher training curriculum of South Korea only provides short term practice teaching. Therefore, we tried to provide pre-service teachers with the opportunity to better understand SSI and to think of their actions and strategies to convey teaching contents by producing a video clip that delivers reconstructed SSI materials to citizens, based on investigation and analysis on their own. Accordingly, the purpose of this research was to evaluate the improvement of pre-service science teachers on understating the nature of SSI and on competencies as professional teachers. Students participating in the research were divided into groups of four and produced a video clip for the general public about the problems regarding social ethics that come with the development of scientific technologies. Diverse topics such as genetically modified food, climate change, nuclear energy, endocrine-disrupting chemicals were chosen to be made of free-form contents. Students chose their topics according to the result of their group meetings and made a project proposal consisting of an overview of contents, intentions of planning, and direction of production. In this process, research participants also set their target and made a storyboard according to it. In this research, a survey was conducted before the contents production to investigate the change in the perception of science and technology, and an additional survey will be conducted after the completion of the production. In-depth interviews of three stage (pre-, inter-, and post) will also be carried out for more deep analysis. The whole process of each in-depth interview will be recorded and transcribed for the data analysis. Supplementary material for the analysis will include the project proposal, the story board, and the final version of complete video clip made by pre-service teachers.

[27P2X-4] Systemic Approach for Improving Science Education in Local Area by Activating Core Science Teachers (*A0590*)

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ABSTRACT Quite a large proportion of teachers have difficulty in teaching science in various reasons. In-service training opportunity is important for many of them to equip new skills and knowledge for effective teaching. Situation of teachers, however, is very busy and few training of science teaching is available every year. Saitama University

established the "Core Science Teacher Training Program" in 2012 in collaboration with the Saitama City and the Saitama Prefecture. The purpose of the program is to train skillful science teachers and certify them as the "Core Science Teacher (CST)" in order to increase formal and informal quality in-service training opportunities for general teachers teaching science in the local area. They are regular teachers, but are supposed to function as an adviser or a model teacher of science teaching for general teachers in the area. The training program for the CSTs consists of five domains: I. Emerging science, II. Effective science experiments, III. Effective science teaching, IV. Developing science talents, V. Communicating science. More than 200 training programs were supplied by the university and the educational boards. By the end of 2015 fiscal year, 34 teachers have been certified as the CSTs. In fiscal year 2015, total of 3800 teachers participated in formal in-service training where the CSTs taught. They give also informal training sessions mainly in their schools. The influence and possibility of this systemic approach to science education of a local area will be discussed.

[27P2X-5] The Study on Change of Pre-service Teachers' Perception about Scientific Inquiry through Scientific Practice and Science Teaching (*A0267*)

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ABSTRACT In science education, inquiry has been considered as a crucial method and subject for learning consistently. Many researchers and teachers agree that it is valuable to learn science through inquiry. However, they agree that there are various difficulties allowing students to perform inquiry as scientist's one in a learning context. According to the studies about perception of teachers, science teachers considered inquiry as a challenging task. And they used inquiry in a restricted form, because of the worry about non-scientific knowledge of students, and several practical restrictions. In other words, science teacher had conflicts between epistemological view and practical view in learning context. During the resolving the conflicts, they could have a chance to grow as an experienced teacher. In this line, this research was performed as the case study, which investigated the pre-service science teachers' perception of inquiry in three context, which are 'what they know', 'what they do', 'what they teach'. Through this research, research program suggest the chance to have the conflicts in the pre-service teachers' education. Participants were 6 pre-service science teachers who attended a laboratory class which connected with a science teaching program for middle school students. The results were drawn by analyzing interviews, participant observations, experimental reports, teaching material, teaching reports, and others. The data were analyzed in epistemological theme which was based on nature of science(NOS). Participants considered inquiry as the activity driven by curiosity of scientists or students, and considered that scientific knowledge was constructed by inquiry or experiment. However, they showed the different perception in contexts of doing and teaching inquiry. When they did inquiry, they defined the inquiry as the optimization process to acquire data which are correspond with theory. And they defined the inquiry as the teaching activity to satisfy teachers' purpose and expectation, when they taught inquiry. According to their re-defined inquiry, the process and feature of inquiry were changed. This result means that the pre-service teachers' perception depended on the purpose which they implicitly decided, and effected the practice of inquiry. It is necessary to investigate the moment of pre-service teachers' growth by reconstructing the meaning of inquiry as the future research.

[27P2X-7] Radiation Education Project in Teacher Education Universities (*A0625*)

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ABSTRACT In Japan, curriculum guideline (Course of Study), for junior high school science was revised in 2008, and radiation education was added in the guideline of school science. After Fukushima Daiichi nuclear power plant accident of 2011, scientific literacy on radiation/radioactivity is socially demanded. Under the circumstance described above, teacher training to produce junior high school science teachers who can teach radiation/radioactivity based on scientific perspective has become an urgent task in Japan. Since 2012, four Teacher Education Universities (Hokkaido University of Education, Aichi University of Education, Tokyo Gakugei University, Osaka Kyoiku University) have been engaged in the "HATO-Project". Under this big project, Tokyo Gakugei University (TGU) has managed a sub-project; "HATO Radiation Education Project" whose objective is pre-service teacher training of radiation education for junior high school science. In this project we started two new subjects "Radiation Education I" and "Radiation Education II" in TGU from 2014. The former one is for the students of the four universities, and is made of lectures and educational experiments. Since this subject is offered intensively at TGU using four days (16 hours) in September, students of three other universities come to TGU and learn about the basic of radiation, radiation measurement, radiation effects on living things through experiments with TGU students. The main target of this subject is the students who have a will to be a junior high school teacher of science, and the number of the students is 20-30. "Radiation Education II" is for the students of TGU, and is made of lectures and practical work such as practice teaching at junior high school. In addition, we have developed teaching materials of radiation education (Video contents and "Teaching Materials Package for teachers"). Details will be reported at the conference. This research was supported by the Japanese Ministry of Education, Culture, Sports, Science and Technology through the Grant for Strengthening National University Reforms for the "HATO Project/Teacher Training Renaissance: Building a Support System to Advance Teacher Education through University Partnership". HATO Project http://hato-project.jp/index.html (May 2016)

[27P2X-8] Training Elementary School In-service Teachers to Develop Insects' e-learning Game Aids by "Advanced Entomology" Training Curriculum (*A0232*)

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ABSTRACT This study is to enhance Technological Pedagogical and Content Knowledge (TPACK) of elementary school in-service teachers, so 28 in-service teachers attend "Advanced Entomology" curriculum containing cognitive concepts, and using the ADDIE model (Analysis, Design, Development, Implement, and Evaluation) to develop e-learning game aids. Secondly, elementary school in-service teachers divided into five groups to develop e-learning Game aids Based on conceptions of Insect (EGBI). Finally, we assess in-service teachers' cognitive concepts by Insect Conception and Teaching Strategies of Questionnaire (ICTS), and assess their EGBI by Insect e-learning game teaching material Evaluation in ADDIE model (IEEA). The result showed that: 1. in-service teachers obtained insect-related cognitive concepts from "Advanced Entomology" training curriculum (t=-6.110, p=.000**). 2. In-service teachers can use various software, like Scratch, Smart Apps Creator, PowerPoint, Augmented Reality, Flash, RPG Maker and VX Ace Software, to develop digital game aids. 3. A total of 5 group' in-service teachers can use ADDIE model to design insect' digital game aids and obtained A ~ AAA grade by the IEEA evaluation.

[27P2X-9] Synthesis of Fragrant Esters and Amides from Aspirin as an Experiment for High School Students (*A0254*)

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ABSTRACT In the textbook of high school chemistry in Japan, some organic compounds which have pharmacological activity were introduced. However, the experiment to learn the mechanism progressively is not known. Aspirin is most general antipyretic analgesic in the world. Active ingredient of Aspirin is acetylsalicylic acid. Acetylsalicylic acid inhibits the generation of prostaglandin by acetylation of serine residue in cyclooxygenase. We thought acetylsalicylic acid will be good acetylating agent from this mechanism. We investigated the synthesis of fragrant esters and amides utilizing acetylsalicylic acid as the reagent for acetylation. We added acetylsalicylic acid (1.0 mmol) and various alcohols (3.0 mmol) to a 100 mL eggplant type flask. After adding p-toluene sulfonic acid (0.10 mmol) as acid catalyst, the reaction mixture was heated with boiling water for 10 min with stirring. In the case of acetylation of amine such as aniline, p-toluene sulfonic acid was not added. The yields of products were measured with GC of 1H-NMR. Utilizing primary alcohols, the acetylation proceeded smoothly and fragrant esters have generated in good to high yields, from acetyl salicylic acid or Aspirin. Acetylation of aniline also proceeded smoothly.

[27P2X-10] Development of a High School Chemistry Experiment: Cumene Method Using Photo-radical Initiator (*A0249*)

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ABSTRACT The cumene method (process) is a major industrial process to synthesize phenol. However, the method is not so appropriate for high school chemistry lab classes because of the longer reaction time in the oxidation step of cumene and the risk of explosion of cumene hydro peroxide (CHP). These problems, longer reaction time, high pressure in the oxidation step and possible explosion risks, need to be resolved. Our laboratory has been already developed methods, coping with the problems, for example, the experiment of cumene method utilizing 2,2'-Azobis (isobutyronitrile) and N-hydroxyphthalimide (NHPI) (Hirose and Inoue, 2012), based on Ishii's method (Fukuda, Sakaguchi and Ishii, 2001). In this study, in order to avoid the risk of heating peroxide, photochemical reaction utilizing radical initiators in the oxidation step of the cumene has been investigated. Cumene, 2,2-dimethoxy-2-phenylacetophenone (BDK) as photo radical initiator and NHPI as radical carrier, were mixed to react under an oxygen atmosphere with UV light (370 nm). The yields of CHP were measured with iodometry. When 20 mol% of BDK and 5 mol% of NHPI were added to 1.4 mmol of cumene, the yield of CHP reached over 10% within 60 min reaction time. Moreover, when acetonitrile was added as the solvent, the yield of CHP reached over 10% within 30 min. But the overall reaction time in the oxidation step of cumene is still long. Thus, we are continuing to investigate various kinds and amounts of organic solvents to obtain much less reaction time. Then, we will proceed to find appropriate conditions in the induction step from CHP to phenol. By utilizing photochemical reaction, the experiment of cumene method will become safe and facile. This experiment can be applied as the advanced teaching material for high school students.

[27P2X-11] Identifying Various Kinds of Fibers: New Experiments for High School Chemistry (*A0255*)

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ABSTRACT For identification of fibers as the student experiment, dyeing method, combustion method and microscope method has been used. However the systematic chemical method, in which fibers were treated as organic compounds, was not realized. In this study, we used eight types of fibers from multifiber test cloth which contains cotton, 6-nylon, acetyl cellulose, wool, rayon, poly acrylonitrile, silk, and polyethylene terephthalate (PET). We could identify five types of fibers (wool, silk, poly acrylonitrile, acetyl cellulose, and PET) with the hydroxamic acid iron (III) method and the lead acetate test. However the method to identify other three types of fibers (cotton, rayon, and 6-nylon) was not established. We have investigated following two methods: (1) Comparing reaction rates of oxidation with $KMnO_4$ and (2) Hydrolysis in H_2SO_4 aq and comparing the amount of reducing sugars with Fehling's reagent. In oxidations in $KMnO_4$ aq, only 6-nylon consumed apparent amount of $KMnO_4$ and the color of reaction mixture changed into brown by MnO_2. With this method, 6-nylon and other fibers (cotton, and rayon) can be identified. Hydrolysis of rayon in H_2SO_4 aq proceeded more smoothly than cotton. As the results of reactions between neutralized reaction mixtures and Fehling's reagent, a red precipitate of Cu_2O generated from rayon and cotton. The amount of Cu_2O from rayon was more than that from cotton. And from 6-nylon, Cu_2O did not generate. This experiment is expected to be useful in general or advanced high school lab class in chemistry.

[27P2X-12] Aerobic Oxidation of Aromatic Aldehydes utilizing a Gold Catalyst Supported on Chitin as the Experiment for High School Students (*A0137*)

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ABSTRACT While oxidation of aldehydes is one of the important reactions in high school chemistry, popular method for oxidation of aldehydes involves a certain risk of chemical injury and environmental load. In this study, we investigated aerobic oxidation of aromatic aldehydes utilizing gold nanoparticle catalyst supported on chitin, as a promising experimental material for high school chemistry classes. The gold nanoparticle catalyst supported on chitin (Chitin-Au) was prepared from H $[AuCl_4]$ aq and chitin powder. At first Au (III) compound was absorbed on chitin at pH8, then reduced into Au0 with $NaBH_4$. We used benzaldehyde as the model substrate in aerobic oxidation. In vial container, benzaldehyde was dissolved into the mixture of NaOH aq and ethanol. After adding Chitin-Au and oxygen, the vial container was shaken by hand for 5 min. The chitin-Au was removed by filtration from the reaction mixture. When H_2SO_4 aq and NaCl were added into the cold filtrate, crystal of benzoic acid precipitated. Oxidation of benzaldehyde in basic solution proceeded smoothly under an oxygen atmosphere at room temperature, in a short time. In order to develop this method as the synthesis of salicylic acid derivatives with drug effects, we tried to oxidize precursor aldehydes. The oxidation of a salicylic aldehyde with oxygen did not proceed even if utilizing the Chitin-Au. But the oxidation of 2-ethoxybenzaldehyde did proceed with this system. From the product of this reaction (2-ethoxybenzoic acid), ethenzamide which is formulated as popular pharmaceuticals can be synthesized.

[27P2X-13] Developing a New Material for Energy Education: A Hydroelectric Generation Equipment Consisting of a Hub Dynamo, Blades (made of PET bottles) and a Frame Made by a 3D Printer (*A0087*)

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ABSTRACT While the public concerns on energy education has been visible after the Great East Japan Earthquake, quite limited is teaching materials for energy education in school contexts. In the science textbooks used by our school, teaching materials on energy conversions appeared only once for three years. In our laboratory, we have been investigating and developing teaching materials of renewable energy, including Dye Sensitized Solar Cell (DSSC) and Savonius-type wind power generator. In this study, we tried to develop a hydroelectric generation equipment as another example of renewable energy. Our equipment consisted of a hub dynamo, eight blades (made of PET bottles) and a frame in between. The frame was produced by a 3D printer. A smart phone, one of the most familiar tools, can be charged by the hydroelectric generation equipment when ordinary tap water (50 liter/m) is falling down from a height of 2 meters. This equipment was possible to attract learners as a learning material relevant to their daily life. Either electric generation equipments or 3D printers are rather popular, but this particular equipment can be effectively utilized for learners both in emergencies and in ordinary situations. Furthermore, since the equipment is constructed within 15 min with lower cost, it is easy for schools to introduce into their energy education classes.

[27P2X-14] Development of Savonius-type Desktop Windmill Power Generator with Flywheel Produced by 3D Printer and Its Educational Effects (*A0122*)

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ABSTRACT The Japanese public has been getting much more aware of the importance of renewable energy (especially wind power generation) than ever. Based upon the experiences of the Great East Japan Earthquake of March 11, 2011, Ministry of Environment, Japan proposed introduction of the highest level of renewable energy system into Japan through its priority policy in 2013, and aimed to introduce wind power generation system diligently. In order to popularize the idea of renewable energy, the public, especially kids and students need to be aware of and interested in renewable energy itself. For this purpose, wind power generators should be set up around them and furthermore, needed should be hand-made typed practical wind power generators for the possible use of the public as well as kids and students. Savonious-type desktop windmill power generators, which have been developed and improved by our laboratory, showed a certain level of educational effects as teaching materials for energy and environmental education. The present study challenged to develop a higher performance (with an accurate overlap ratio) model of the generators, whose parts were produced by 3D printer. In addition, it was equipped with a flywheel and the windmill was possible to rotate stable under the unstable wind conditions. The resultant generator was possible not only for the use as a teaching material of energy education, but also for the practical use. Educational effects of the introduction of the developed generator in 9th graders' science classes at a public school are also reported.

[27P2X-15] ***Sugoroku*** **is an Effective Simulation Board Game for Advancing Knowledge of Diet Management and Enhancing Welfare of Animals Kept in Japanese Elementary Schools** (*A0545*)

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ABSTRACT In recent years studies have found that children have little opportunities to come in contact with nature. Guidelines at Japanese elementary schools have emphasized the importance of contact with nature through taking care of animals and plants. As such, many Japanese elementary schools have kept small animals traditionally for educational purposes. However, some teachers have little knowledge on rearing animals and plants because they lack experience working in natural surroundings. As a result, some animals are subjected to unsatisfactory rearing conditions that may compromise animal welfare. The present study was aimed at developing a teaching material on rearing animals for university students (especially those in the teacher training course). Firstly, we developed sugoroku (a Japanese 'snakes and ladders' type of board game) for advancing knowledge on diet habits and food preference of rabbits, the most popular animals reared in

schools. Next we conducted pre- and post-tests to 37 students to measure their knowledge level of diet management for rabbits. Wilcoxon signed-rank test was used to compare differences in the mean of the test scores before or after the game. Questionnaire survey was also conducted to examine the problem and solicit improvements for the game. There was a significant increase in the mean score after the game (Wilcoxon signed-rank test, $p<0.05$). In addition, results also revealed that most players found the game enjoyable besides being instructive. In conclusion, it was found that sugoroku could improve players' knowledge on diet management of rabbits. In the future, we should further improve the quality of the game and validate its learning effect on students in the teacher training course.

[27P2X-16] Cultivating East-Asian 'Shared Leaders' through the Activities of Making a Water Heater by Plastic Bottles: A New Curriculum Materials for Environmental and Energy Education for High School Physics Classes (*A0427*)

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ABSTRACT The COP21 forged the Paris Agreement, in which the rise in global temperature should be restrained to below 2 degrees Celsius. While the national governments and enterprises around the world are asked to take active actions toward the goal, citizens are the agency taking a key role to make it real. Especially, it is inevitable to encourage the younger generation to think globally, take their actions locally and make societal decisions as 'shared leaders' for sustainable communities. However, there are few curriculum materials, making students interested in environmental and energy issues, being aware of its significance by continuous monitoring of environmental factors by themselves. In this study, developed and used were a Water Heater by Plastic Bottles for secondary physics classes. The students (of a Japanese private high school) could make their own water heaters and monitor the changes in water temperature in the heater. Their activities and findings were presented as 'a way of utilizing renewable energy' to their Korean sister school's students. We are also planning to develop an data exchange program with Cambodian students, whose environmental situations are quite different from those of Japanese counterparts. How and to what extent enhanced were Japanese students' environmental and energy awareness will be presented. Also, proposed will be a possibility to collaborate with elementary and junior high students by utilizing the curriculum material, 'tower type Water Heater by Plastic Bottles.'

[27P2X-17] A Factors Affecting Students' Learning Activity after Scientific Experiments (*A0233*)

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ABSTRACT This study investigates factors which have positive influence on students' motivation in future learning after they observe science experiments. The investigation is conducted with 22 high school students of second grade. They are required to make prediction about the weight of a magnet when it is floating in water. They make evaluation of the whole experiment process using a five-degree scale from the following perspectives: surprisingness, interestingness, and difficulty of the task. Afterwards, the author investigates the relationship among students' expectation towards the experiment, the experiment result, students' preference and purpose in science learning. As a result, students indicate more surprisingness, interestingness, and difficulty in handling the task when the experiment results are out of their expectations. However, students who are relatively highly motived in science learning and more willing to challenge difficult tasks, tend to move on to further self-initiated study after the experiment. Therefore, conclusion is made that students' participation in an experiment and the surprising experiment results don't necessarily direct to their further learning activity. Motivation is the factor which contributes most to their potential future learning.

[27P2X-18] Process of Thinking and Difference of Rationality in the Hypothesis Formulation (*A0287*)

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ABSTRACT PISA2015 defined three competencies for scientific literacy: Explain phenomena scientifically, Evaluate and design scientific enquiry, Interpret data and evidence scientifically. Among them, "Explain phenomena scientifically" includes ability to "Offer explanatory hypotheses" (OECD, 2013). It has recently been determined that formulating an explanatory hypothesis to explain a discrepant event is important for students' conceptual change (Park, 2006). However, few studies have focused on the process of thinking in formulating an explanatory hypothesis. On the other hand, some factor that relate rationality have been shown in psychology. For instance, Manktelow (2012) refer to relation between Need for Cognition (NFC) and rationality. But, there is no study that make reference to factor that relate rationality in formulating a scientific hypothesis. The purpose of this study is to explore process of thinking and to describe difference of rationality in formulating an explanatory hypothesis. In this study, 16 under graduate school students (8 male and 8 female) were surveyed by interview research about thinking process of formulating an explanatory hypothesis with think-aloud and semi-structured interview method. Because of we attempted to clarify some small step processes at formulating explanatory hypothesis by qualitative method. We demanded to think six unfamiliar situations and estimated process of thinking from interview protocols. These were scored rationality of thinking process according to the evaluation criterion, and classified students into 3 levels; low group 0-16.04, middle group 16.04-19.46 (it based on 95% confidence interval of total score), high group 19.46-. Additionally, NFC is measured by questionnaire survey. The results of this analysis revealed following: 1) Process of thinking in formulating an explanatory hypothesis composed of 6 processes. Basic processes are "understand the circumstances of problem", "identify variables", "realization of factor/relationship" and "express the idea as their own hypothesis". Optional(depend on the necessity) process are "consider goal" and "think critical about hypothesis". 2) Rationality in formulating a scientific hypothesis correlate with NFC ($r = 0.532$). 3) Students in high group showed more critical protocols

about their own thinking at the process of "identify variables" and "realization of factor/relationship" than the other groups.

[27P2X-19] Investigating on Pre-service Science Teachers' Understanding and the Degree of Certainty of Electromagnetism Concepts (*A0537*)

Jihyeon Jeong* and Sung-Won Kim+
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ABSTRACT Among the fields in physics, students usually feel difficulties and boredom in electromagnetism. Since the process of electromagnetic interaction is invisible and the theory is abstract compared to other fields such as mechanics and optics, its concept learning is considerably challenging for students. Many students graduate from high schools without proper understanding of electromagnetic concepts. Furthermore, even pre-service and in-service science teachers sometimes have wrong concepts of electromagnetism. Since teachers' wrong concepts directly affect students' concept-acquisition regardless of their cognitive abilities, studies on teachers' concepts should be conducted prior to the studies on students' misconceptions. This study produced an indicator by adding an item to measure the certainty into the existing BEMA (The Brief Electricity and Magnetism Assessment) in order to explore pre-service science teachers' understanding and the degree of certainty of electromagnetism concepts. The study was performed for 28 preservice science teachers who took a class of General Physics in the college of education located in Seoul, Korea. The existing electromagnetism BEMA had the purpose of measuring the electromagnetism concept understanding of the students who took a class of Basic Electromagnetism (Chabay and Sherwood, 1997), which was comprised of 31 multiple-choice questions to confirm the key electromagnetism notions that commonly appeared in Basic E&M curriculum and Matter and Interaction curriculum. To examine the students' degree of certainty in terms of basic knowledge of electromagnetism, students were asked to mark the certainty degree given with the concept question. Their certainty degrees were classified into 4 categories: very low (0~25%), low (25~50%), high (50~75%), very high (75~100%). The students should mark the corresponding section per each question. The results of the analysis are as follows: (1) Compared to Difficulty Index in Evaluating an electricity and magnetism assessment tool, Korean students showed higher understanding in the question of Coulomb's law and lower understanding in the question of potential difference. (2) In the question of electric circuit, students showed low degree of certainty. (3) In the question of comparing the level of electronic current and the brightness of bulb and the question of marking the direction of electric field or magnetic force, it was revealed that the degree of understanding was low, while the degree of certainty was high.

[27P2X-20] Analysis on the Science-Related Activity Aims in the 'Guide for Educational Activities & Materials for Kindergarten' for Nuri Curriculum of Korea (*A0532*)

Jihye Kim* and Sung-Won Kim+
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ABSTRACT Early children are curious and imaginative with unlimited potential. In addition, they constantly explore the outside world and their surroundings through the short questions, which makes we call them as 'Natural-born scientists'. Therefore, education during early childhood is important to breed up future-talented people with scientific literacy. Accordingly, Republic of Korea developed a curriculum called 'Nuri-Curriculum' of science-related activity for the age of 3-5 based on the revised Early Childhood Education Law and Infant Care Law in 2012 (the Ministry of Education, Korea, 2012). Teachers for early childhood in Korea usually design and carry out their educational activities using 'Guide for Educational Activities & Materials for Kindergarten' (GEAMK) for 3-5 year old Nuri Curriculum. It shows the possibility that GEAMK is useful for important materials in field of childhood education. It also faithfully follows the national curriculum in kindergarten and contains various activities even if it is not a text book that teachers should use. Therefore, activities and activity aims described in GEAMK are important factors to implement the curriculum. The activity aims in early childhood curriculum should be able to suggest promising perspectives and expected changes of early children with pointing concrete direction to select and organize the activities. In other words, description perspicuity of the activity aims and directionality of activity aims are significant for the curriculum in kindergarten. We firstly analyzed the verbs to describe the science-related activity aims in GEAMK for 3-5 year-old Nuri Curriculum to figure out the description perspicuity. Second, we analyzed the directionality of the Aims using domain classification of Bloom's taxonomy (Bloom et al., 1956). We used 931 Science-Related Activities out of all 2,116 activities in GEAMK. For analyzing the verbs, 30.1% of science-related activity aims were written in 'can be interest in', 14.1% were written in 'know', and 10.2% were written in 'participate'. For the directionality of the aims, the cognitive domain accounted for 42.7%, the affective domain accounted for 37.3%, and the psychomotor domain accounted for 20.0%. This study will be able to show importance of the perspicuity of activity aims and propose improvements of science-related activity aims and to suggest future trends of science-related activities for kindergarten.

[27P2X-21] An Analysis of Science-Arts Integration Activities in Middle School Science Textbooks of Korea (*A0540*)

Jungwoo Lee* and Sung-Won Kim+
Ewha Womans University, Korea

ABSTRACT Recently many science educator and researchers emphasize integrated education through art education in science education. There are several studies about the educational effect of science linked art (Jakobson & Wickman, 2008; Milne, 2002). Those studies asserted that students can have an ability to reason and in-depth understand science through the art. Through art education, students also can understand scientific phenomena by using various senses (Maes, 2010). Therefore art education has been emphasized in science education. The aims of this study are to identify the present status of science and art integration activity described in science textbook of middle school and to find artistic factors. To this end, the physics parts in 9 science textbooks for middle school from 2009 modified National Curriculum were analyzed. And the

type, function, and roles of artistic activities described in science-art integration activity were classified. As results of the research, we found that science-art integration activities suggested in the textbooks were applied to visual art, audio art, physical art, and liberal art with equal frequency. However, the integrated type of art like play and dance was not suggested. In terms of functional aspect of art activity, art was just introduced simply to stress or highlight science study and was played to be used as materials in indirect ways. From the results of artistic factor analysis, the expression factors of creative and abstract things of virtual reality appeared most. Artistic activities were applied frequently in most textbooks. Based on the results of analysis, it seems that art needs to be applied to diverse tools like learning motivation, application to learning and usage rather than to be used in order to understand the concepts of science. In order to understand abstract concepts like power or energy in physics, visualization activity is needed. In the activities of applying and using science, not only liberal and artistic activities like science writing but also using diverse art forms are required. In addition, by asking direct art activities to students, the direct activities of art functions are required as well. In order to include a variety of artistic factors, science and art integration activities need to be developed.

[27P2X-22] Research on Pre-serviced Chemistry Teachers' Instructional Design Abilities (*A0125*)

Xiaohui Long* and Wenhua Zhang

College of Chemistry, Central China Normal University, China Mainland

ABSTRACT In 2002, the Organization of Economic Co-operation and Development (OECD) published a report about teachers' supply and demand. It indicated that teachers' teaching ability is not only "a crucial factor in determining the quality of student learning", but also "the guarantee for improving a country's national quality, promoting social justice and economic development". Therefore, the study of pre-serviced teachers' teaching ability is necessary. In order to qualifying the pre-service teachers' teaching design abilities, I choose "pre-serviced chemistry teachers' teaching ability" as my research object. Firstly, I clarified the core conception of "chemistry instructional design ability". It contains the analysis of textbook, student, teaching target, difficult points, teaching strategies and teaching process. Secondly, according to the core conception I compiled a measuring scale for the instructional design abilities of pre-service teachers. To make the scale more authoritative, I interviewed a few exports and collected their views about the scale. Finally, I analyzed 28 sheets of "great instructional design". These instructional designs were submitted by students who enrolled in 2012 in college of chemistry, Central China normal university. Through statistical analysis, I found that most of the students has good abilities of teaching design, but there are also some prominent problems as follows: (1) Their understanding of the importance of teaching materials & students analysis is not enough. And the analysis level is too plain and shallow. (2)Expression of teaching target isn't standardized. The description of "emotional attitude & value" is vague and unclear. (3)The amount of difficulty expected to be solved in one session are not balanced. (4) The construction methods of knowledge system need to be improved. (5)Some designs in teaching activities were invalid. Some difficult learning goals were not fully achieved. This paper will give an analysis of attribution to above problems and will provide some suggestions. I hope my research can contribute to the relevant departments to formulate the training scheme and other cultivation of the free normal students.

[27P2X-23] Japanese Lower Secondary Science Teachers' Convictions on Scientific Explanations of Popular Natural Phenomena and Their Teaching (*A0337*)

Satoshi Murakami* and Yasufumi Kawamura[+]

Tokyo University of Science, Japan

ABSTRACT While many empirical studies on children's or students' ideas on natural phenomena (called 'naive conceptions') had been reported, studies on science teachers' naive conceptions are still few. In Japan, since the science teacher certificate is not separated into respective areas, that is, physics, chemistry, biology, and earth sciences even at the secondary levels, secondary science teachers without a strong physics background happen to and need to teach physics, especially in lower-secondary schools. This means that lower-secondary science teachers' level of knowledge and understanding of fundamental physics are expected to be rather differentiated. However, there are few empirical studies on this issue. Thus, the present study aimed to uncover Japanese lower-secondary school teachers' convictions on scientific explanations of natural phenomena (in physics area), in which naive conceptions are popularly found among students. Total 110 lower-secondary science teachers in Saitama Prefecture were voluntarily involved in this survey with a questionnaire consisting of 12 popular phenomena in physics area. The major findings, which will be presented, are as follows: (1) Most of the teachers were convinced of scientific explanations of such popular phenomena, but they felt difficulty in teaching such topics to lower-secondary students, especially the topics on the relationship between force and motion, which must be taught in lower-secondary science classes, for example, motion under continuous application of force, or motion without force, (2) Most of the teachers understood such scientific explanations during senior-secondary days, while the topics were taught during their lower-secondary days, and (3) Most of them also convinced of scientific explanations on the phenomena, force and motion, which are treated in upper-secondary physics classes, but they showed very little confidence in teaching such topics in the science classes. [Draft]

[27P2X-24] Identifying Conceptions of Teaching Science (COTS) of Pre-service Elementary School Teachers in Taiwan (*A0098*)

Tzu-Chiang Lin

Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, Taiwan

ABSTRACT This study aims at revealing pre-service elementary teachers' conceptions of teaching science (COTS). Conceptions of teaching refer to teachers' understanding and belief regarding nature of teaching. Such conceptions mainly stem from teachers' everyday practice and cognitively associate with their design, strategies, as well as implementation in instruction. It is hence worthy of noting such conceptions of pre-service teachers who lack

for authentic teaching experience. Due to the domain-specific nature of teaching, this study especially invested research efforts on exploring pre-service teachers' conceptions of teaching for science discipline. The research approaches were twofold. In the first part, this study conducted a systematic review on literature published after 2012 regarding conceptions of teaching science and tried best to identify science teacher educators' consensus of such a construct. The results indicated that researchers recently focused on the five dimensions of COTS, including: 1. Teaching science as assistance for students' construction of science knowledge or process skills; 2. Teaching science as achieving goals of scientific instruction or science learning; 3. Teaching science as development or changes of epistemic belief for science; 4. Teaching science as understanding of student's academic achievement or notions toward learning; 5. Teaching science as improvement of students' motivation and engagement in science learning. The second part of this study utilized the aforementioned findings as theoretical background to develop a phenomenographic approach based on qualitative interviews to elicit pre-service elementary teachers' COTS. A total of 45 pre-service elementary teachers in Taiwan participated in this study as interviewees. The findings from analyses on interview results showed that the pre-service elementary teachers majorly conceptualized science teaching as: 1. Knowledge transmission; 2. Assessment and evaluation; 3. Improving motivation and engagement; 4. Conducting scientific practice; 5. Fostering knowledge construction; 6. Supporting higher order thinking; 7. Shaping multiple perspectives for science knowledge. The conceptual model revealed in this study may be reasonable foundation for developing quantitative research tool in consecutive studies. This emerges the possibility to conduct larger scale investigations in the future as to simultaneously adjust the theoretical framework of COTS and further provide fruitful information for improving science teacher education.

[27P2X-26] A Study on the Effect of Teaching Electric Voltage to Elementary School Students on Their Understanding of Electricity (*A0134*)

Toshiyuki Ishii*[+1], Riku Yatomo[1], Koichi Morimoto[1], and Akihiko Ito[2]

1. Nara University of Education and 2. Utsunomiya University, Japan

ABSTRACT Most studies on the instruction of the electricity for elementary school students have focused on teaching the concept of electric current. Actually the concept of electric voltage has not been taught in elementary school in Japan. The purpose of this study is to clarify whether elementary school students' (10 years old) understanding of parallel and serial connections of dry cells improved by teaching the concept of electric voltage. Students in the experimental group were taught the concept of electric voltage for 20 minutes using the analogy of water flow, such as, the dry cell is like as a water pump to uplift water and the voltage stands for the height of uplift. We taught elementary school students that the serial connection of dry cells corresponds to piling up dry cells vertically, while the parallel connection of dry cell is equivalent to put them side by side horizontally in order to develop the image of electric voltage as "height". The experimental group who was taught electric voltage showed a significantly higher achievement score than the control group in the post-test and follow-up test in 1 month later and 3 months later. Moreover, the way of thinking about the brightness of miniature bulb in both groups was different to each other on the circuit in which three dry cells were connected parallel. Additionally, students in the experimental group showed more scientific answers in a descriptive question about electricity compared to the control group. The concrete understanding about the phenomena of electricity may promote their scientific way of thinking. Since the electric voltage is not taught in elementally school in Japan, students can't explain the reason why the brightness of miniature bulb is brighter in circuit with serial connections of dry cells and doesn't change in circuit with parallel connections of dry cells compared to the circuit with single dry cell. The results of the present study showed that we can introduce the concept of electric voltage even in elementary school science class if we exercised ingenious way of teaching, and the concept of electric voltage is worth teaching in elementary school. [Draft]

[27P2X-27] Research on Specialized Courses Teaching of Science Majors in Colleges and Universities from the Perspective of Interdisciplinary Knowledge Communication (*A0266*)

Linna Yao

Qujing Normal University, China Mainland

ABSTRACT Through a diagnosis of modern specialized courses teaching of science majors in Chinese colleges and universities, this research identifies the characteristics of the present situation, crisis and dilemma of specialized courses teaching as well as the root causes of these problems. On this basis, taking specialized courses teaching of science majors as an example and centering on three basic clues, namely educational objects and educators, teaching targets, and content and knowledge communication, the author first explores interdisciplinary knowledge communication and collaborative learning. Then, based on this, an interdisciplinary ecosystem of specialized courses teaching of science majors is built and the cross structures between different elements in the system as well as the collaborative mechanism are discussed. At the same time, the education system is evaluated through classroom experiment comparison and experts investigation. To complete the research contents, this research project proposes to make a comprehensive use of survey method, interdisciplinary research method, comparative research method, case study method, classroom observation method and so on, carry out interdisciplinary researches and empirical researches to a certain degree, and finally extract the theories and methods of specialized courses interdisciplinary teaching of science majors in Chinese colleges and universities. [Draft]

[27P2X-28] Exploring How Place-based Education Practice Can Improve Rural Students' Learning Effects and Perspectives Concerning Science Learning (*A0283*)

Chiung-Fen Yen* and Hsuan-Fang Hung

Providence University, Taiwan

ABSTRACT Providing an appropriate set of education for students with diverse backgrounds continue to be a critical

challenge in many countries. Researchers have identified that a gap between students' life experiences and knowledge system in formal education settings has influenced students' learning experiences greatly, especially for diverse students and in science learning (Wu & Tsai, 2009; Chang & Lo, 2014). Waller and Barrentine (2015) further pointed out that curriculum may play a role in isolating students from learning because of their unfamiliarity with the knowledge system presented to them. Therefore, schooling experiences play a vital role in students' ability to develop a knowledge system which is in harmony with their world views. Therefore, some researchers started to pay attention to how living context plays a role in students' learning process. However, very limited research has targeted on rural students' learning experiences to identify what are critical components in curriculum design, especially in the subject of science. This research has taken students' cultural context into consideration, and choose to adopt Place-based Education (PBE) theory as the curriculum framework. PBE have identified students' cultural knowledge, community resources, and the living environment as important components to be integrated into the curriculum design (Sobel, 2004; Evans & Kilinc, 2013). Data has shown that immigrant students, indigenous students, and students with low socio-economic status have a great representation in rural communities in Taiwan (Ministry of Education, 2015). Therefore, rural community context intersects with cultural diverse backgrounds of students can form a very different set of values and knowledge system. Thus, taking cultural backgrounds and community context into consideration in teaching practice is very important. Hence, the purpose of this research is to explore whether PBE environmental education module can improve students' learning effects, motivation, and sense of environmental identity. Qualitative research methodology has been used in this research. 3 unit lessons has been developed and they are "Campus Plants", "Seashore Plants", and "Plants are sick" respectively. An elementary school close to a huge wetland was invited to participate in this research, and 27 third grades students, and 1elementary school teacher participated in this research. All unit lessons have been developed by the collaborative effort by researchers, 2 college faculty who serve as the consultant for this research, and the teacher. Interviews were conducted before and after the unit lessons to explore what students have learned and whether their perspectives concerning science learning have been changed. Findings from this research indicate that students' perceptions towards "scientific knowledge" has been expanded to include what they have directly observed, not limited to "reading books" and "learned from teachers". Another finding has indicated that outdoor education model using PBE as curriculum framework has assisted students to initiate their automated learning process, and students show to use their daily experiences to interpret scientific knowledge. Based on research outcomes, it can be concluded that PBE environmental education lessons can be a good curriculum model to meet students' diverse needs and bridge the gap between their home environment and the school setting.

[27P2X-29] The Teaching Strategy and Modeling Process for 'Scientific Model Co-construction' Using Smart Devices (*A0022*)

Hyunseok Oh
Seoul National University Middle School, Korea

ABSTRACT The purpose of this study was to investigate the teaching strategies and modeling process for 'scientific model co-construction' using the smart devices in the atmospheric science classes. Atmospheric lessons were videotaped in 8th grade classes in Seoul, Republic of Korea in 2015. The contents of smart education for atmospheric lessons was configured with two topics atmospheric general circulation and extra-tropical cyclone. Form of teaching and learning model was based on the social co-construction of scientific models with the devices and software for smart education. In lessons, group composed of four students jointly used a smart pad-SAMSUNG GALAXY NOTE 10.1 2014 edition to express their co-construction model. We analyzed lessons and students' expressed models. The results of this study were as follows. First, when students presented their group model to other groups, the teacher arranged the presentation order from the group whose model was the most different from the target model. Through this, the teacher could efficiently manage class time. Second, to use of smart devices for co-construction and presentation of the groups' models was a major role in helping to construct the model of class, especially, within the modified GEM(model generation, model evaluation, model modification) evaluation cycle. Implications on how to effectively use smart devices and software in 'scientific model co-construction' are discussed in this paper.

[27P2X-30] A Pilot Study on Developing and Validating a Fixation-Based Scaffolding Learning System (*A0271*)

Chung-Yuan Hsu*[1], Guo-Li Chiou[2], and Meng-Jung Tsai[+2]
1. Department of Child Care, National Pingtung University of Science and Technology and 2. Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, Taiwan

ABSTRACT The purpose of this study was to develop and validate a fixation-based scaffolding learning system. Using eye tacking methodology to probe how learners process text and graphic information for science learning has been receiving great interests in the recent years. Due to evolving eye tracking technology, the price of current eye tracking devices are much less expensive than before. A good example is the Eye Tribe tracker, costing $99. But, the low-cost eye tracker normally comes with hardware and Software Development Kit (SDK) merely. That is, one still needs to conduct programming for analyzing eye tracking data (e.g., detecting fixation, or designing areas of interest). Although there exists some open source eye-tracking software (e.g., Open Gaze and Mouse Analyzer, OGAMA; PyGaze), using eye trackers not only for capturing eye movements, but also for detecting students' learning difficulties and providing instant scaffolding is challenging. To fulfill this purpose, using the same software to develop eye-tracking program as well as the interactive content becomes greatly essential. Therefore, based on the platform of the EyeTribe, this study attempted to develop a fixation-based learning system. In this study, we developed a fixation identification program by utilizing the Unity, a

free game development software. After the development, a series of tests were conducted for its validity, in which we compared the accuracy and precision of the EyeTribe system with another well-established eye-tracking system, FaceLAB 4.5, which has been employed in many human-computer-interaction and learning studies. First of all, we developed a program to identify fixations from the raw data (a sequence of sampling points, or gaze points)collected by the EyeTribe, according to the dispersion-based algorithm which has been proved and suggested to use for fixation identification in the prior literature (Salvucci & Goldberg, 2000). The criteria used for testing in this study was that once a sequence of the gaze points were allocated within a radius of 40 pixels and accumulated a duration of time more than 150 ms, they were regarded as a fixation. The dwell time and the radius was designed to be two parameters for this program. Several tests were conducted in this study. First, we used 14 sets of designed raw data to test the correctness of the program and made revisions repeatedly until the output data for fixations were all correct. The data included fixation location (x and y), pupil diameter x, start time, end time and duration of time. Second, we tested the program with the real raw data collected by the FaceLAB in four prior cases and finally get an average accurate rate of 99.94%. Lastly, three graduate students were invited to test the EyeTribe. Each one was told to look at a picture for three different durations: no blink, 1 minute, and 5 minutes. Sampling rates with 30 and 60 f/s were adopted. The results show that, the former was 100%, 99.74%, and 98.38%, whereas the latter was 99.93%, 92.05%, and 87.02%, respectively for no blink, 1 minute, and 5 minutes. The above findings suggest that the fixation-based scaffolding learning system developed in this study were valid and feasible. The application of the system will be discussed in the conference.

Poster 2Y (27th, 11:30-12:50)

[27P2Y-1] A Case Study of Craftsmanship Courses using a New Distance Education System for the Overseas Educational Institutions of Technical Education (*A0567*)

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Salesian Polytechnic Tokyo, Study Group on M2M, Japan

ABSTRACT The main purpose of this study is the development of a new distance education system between Salesian Polytechnic Tokyo and overseas educational institutions for technical education. For this study an intensive course has been created and applied at the University Technology MARA (KTJ) in Malaysia. In order to collect basic data for the new distance education system, the program has been started in 2012. By 2013 we finished the making of the lecture-contents for the new system. For the reason of a fast development of the system, a pre-test appliance of the same system for the Mongol Kosen (MK) in Mongolia, Salesian Polytechnic could start the delivery-lectures in the academic year of 2014. This new system included the using of Mirror type server joined with web conference system. In order to reach a successful result, the full appliance of this education system between Salesian Polytechnic Tokyo and Mongol Kosen is programmed to start in the academic year of 2016. In addition, the Science school has started since 2015, by using web conference system between Salesian Polytechnic Tokyo and Mongol Kosen. The following results were found. First, the interactive learning class has been start by using mirror type server joined with web conference system. Second, the mirror type server is usable in not only the interactive learning class but also craftsmanship course class.

[27P2Y-3] Avoid Obstacles Car and Can Control with VR (*A0616*)

Hyunjae Cho* and Sung woo Huh+
Soong Moon Middle School, Korea

ABSTRACT <Who we are> We are both Middle school third grader students (age 16) in korea. We were started this project with the Science club in school called 'STEAM' that is coached by Yun Hee choi a science teacher. <Motive of this project> Nowadays there are many car accidents. So we should think about how to solve this problem. We think one way to solve this problem. Also When we play the game we feel that we are just playing the game and do not feel anything else. So we want to make something better something that can excite us. Then we think 'How about funsion them together' that was why we start to develop Avoid obstacles car <Our project> Our car go front unless there are not something in front it. If something is in front of it the car stop and spin clockwise until there is nothing in front of it. Also there are LED on it and it is green usually but become red when something is coming toward to our car. In addition, we are going to add application that we can see in real time through VR devices. We can control the camera view and direction of the can with wireless remote controller. Also we can use it at car racing <Conclusion> Our car perfectly works with IR remote controller, And the Conflict prevention system work well. We can feel mood of the driving with this car. But the maximum distance of remote controller is the problem which we have to solve.

[27P2Y-8] A Teacher's Knowledges in Fraction Division Teaching: A Textbook-based Design (*A0380*)

Shu-I Chang
National Taipei University of Education, Taiwan

ABSTRACT Fraction division is a difficult concept for most of the students, and teachers' knowledges are important factors to affect students' mathematics learning. Thus, the issue of teachers' knowledges in fraction division teaching becomes more critical. Moreover, as textbook is a main source of mathematics teaching, this study chooses the unit of fraction division in sixth-grade textbook as main interview materials to explore a teacher's knowledges in fraction division teaching. The data of this study was collected from a primary school teacher, Mrs. Lee, who has been teaching mathematics in grades 5-6 for ten years; the method used is in-depth interview, and the interview problems are textbook-based design. Here are some discoveries of this study. First, Mrs. Lee can anticipate what students are likely to do and interpret their incomplete thinking. She ascribes students' mistakes in fraction division to being influenced by fractional addition and multiplication, erroneous usage of invert-and-multiply algorithm, not comprehending the meaning of the questions, and confusion of units. Second, Mrs. Lee can choose useable strategies to respond to students' errors, for example, asking the students to understand the problem semantics,

to come up with the mathematical expressions, to learn the concepts through practice and small group discussion, and to lead the student to think about the significance of the numbers to check whether the answer is reasonable. Third, Mrs. Lee adopts materials provided in textbook but to teach in different sequences. The activities are arranged in the following order- 'a fraction divided by one with the same denominator', 'fraction divided by a whole number', 'one whole number divided by a fraction', 'a fraction divided by one with different denominator', and the problems that remainder isn't zero are arranged to above activities.

[27P2Y-10] Development of Problems and Experimental Apparatus of Domestic Physics Competition for International Physics Olympiad and Its Implication to Middle School Science Education (*A0553*)

Yasuhiro Kondo*, Kazuo Kitahara+, Hitoshi Kondo, Hiroo Totsuji, Masuaki Matsumoto, Tadayoshi Tanaka, Hiroyuki Yoshida, Tsutomu Nakayashiki, Hiroshi Kezuka, Kaoru Mitsuoka, Isao Harada, Tadao Sugiyama, Masatoshi Namiki, Shuri Hasegawa, Masao Ninomiya, and Msasataka Ariyama

Tohoku University, Okayama University, Tokyo Gakugei University, Kanazawa Institute of Technology, SEG, Okayama Ichinomiya High School, Tokyo Engineering University, Osaka University, Okayama University, Kawaijuku, Takachiho University, University of Tokyo, Okayama Photo-Quantum Research Institute, Tokyo Tele-communication University, and Tokyo University of Science, Japan

ABSTRACT Since 2005, we have been organizing domestic physics competition every year to select contestants of International Physics Olympiad. Contestants are high school students, whose ages range from 15 to 18.

The domestic competition consists of two stages; the first stage selects 100 students out of all applicants, nowadays, about 2000 students by giving nation-wide one-day written exams and by requiring applicants to do experiment on the given theme and to send reports. Selected 100 students are invited to the second stage, which is actually a four-day camp, consisting of theoretical exam and experimental exam, each of which is five-hour duration, as is the case of International Physics Olympiads.. Since the beginning, we have been improving the exams and associated apparatus. In thus conference, we will show the development of experimental themes of the first stage and the development of experimental apparatus of the second stage by showing the actual apparatuses. The goal of our activities is not just for winning the international competition, but more for finding talented students and fostering them so that they may be more appropriately appreciated an the society. We will show the results of the survey of impact of domestic competition on the future of participant students as well as on the society around them.

[27P2Y-11] A Review of Modeling Research in Science Education in Japan (*A0174*)

Hiroshi Unzai*+ and Takuya Matsuura

Graduate School of Education, Hiroshima University, Japan

ABSTRACT Models and modeling are key tools for scientist, science teachers and science learners (Coll, France & Taylor, 2005). In recent years, the value of models and modeling to science education has been increasingly recognized among the science education reform movements (Gobert & Buckley, 2000). Lehrer & Schauble (2006) indicate that developing student's modeling competences is important in science education. In order to clarify the recent trends and future direction, this study review the modeling research in science education in Japan. Based on the result of research article search engine 'CiNii', we analyzed 35 articles that relate to modeling research in science education in Japan. These articles are divided into three research methods: theoretical research, survey research and practical research. We described the recent trends and future direction of modeling research in Japan based on the results of this analysis and comparison with the other international research articles. These analysis and comparison indicate following: a) there were few theoretical researches in Japanese journals; b) the survey research focused on student's image (model) of natural phenomena, thinking process with models or understanding the role of scientific models; c) most of the practical research focused on conceptual formulation. This result indicates that we have to discuss theoretical framework of modeling from the aspect of Japanese context (e.g. Japanese science curriculum, Japanese student's character) and we should focus on student's modeling competences.

[27P2Y-12] A Case Study from Free Semester in Middle School: Applying STEAM Using High-Tech Display Products (*A0004*)

Kyung Mee Lee*, Kyuseong Lim, and Soo Yong Kim+

STEAM Education Center, KAIST, Korea

ABSTRACT Developing science and technology provides a lot of high-tech display products in real life. This study presents 1) to understand the principle of science from high-tech display products, 2) to provide outcome of STEAM pilot class in a middle school, and 3) to analyze its results using a survey study. Particularly, this study contributes to understanding and developing an educational programs of high-tech display products through supporting from science, technologies and career experiences. Moreover, It is urgently necessary for vitalizing industries-schools-research institutes alliance to develop the proper educational programs. [Draft]

[27P2Y-13] Development of Project-Based Lesson Model in Junior High School Chemistry: Exploring Desirable Utilization of Plastics (*A0611*)

Hiroshi Tanso[1]*+, Norikazu Umehara[2], and Hiroki Fujii[1]

1. Graduate School of Education, Okayama University, and 2. Togo Junior High School, Tottori Prefecture, Japan

ABSTRACT Innovative science lessons to promote students' independent problem solving have been sought in Japan. The idea "Project," which has been practiced a long time ago (Frey, 1982), can be applied to develop lessons. This study aims to propose a project-based learning model for junior high school chemistry by incorporating the following elements (Krajcik & Shin, 2006): Driving question to anchor in a real-world situation that students find meaningful and important; students' collaboration to investigate questions and ideas; and creation of artifacts to externally represent students' constructed knowledge. Through lessons on plastics, the students are expected to understand materials for daily use from scientific viewpoints and to make appropriate judgments regarding the solution of problems related to such materials: This is the final goal in their

problem-solving activities. The series of lessons was conducted with 44 Japanese students in the seventh-grade in February 2016. Firstly, a driving question "How should we utilize plastics in the future?" was presented to the students. In order to obtain general information on various materials including plastics, they learned about the differences between organic and inorganic materials, metals and nonmetals, and the features of plastics while collaboratively experimenting on such materials. Secondly, they also learned about the influences of plastics on the natural environment and the development of a new material, bioplastics. Finally, they completed their report, as a creation of artifact, to answer the driving question given at the beginning of the lessons. Some findings that emerged from the questionnaires and the above-mentioned report are as follows. (1) Regarding the merits of plastics, the students were aware of the lightness, softness, and durability of plastics at the beginning of the lessons, and through the lessons, they understood the natures of plastics: long-lasting, rust-proof, resistant to electric and thermal conductivity; they also learned the various utilities of plastics. (2) Regarding the demerits of plastics, the students understood the difficulty in treating plastics in the natural environment and the use of fossil fuels as raw materials for plastics by the end of the lessons. (3) Regarding the desirable utilization of plastics, the students expressed their ideas based on their appropriate judgments: Recycling of plastics, gradual expansion on the use of biodegradable plastics, and creation of innovative plastics by the end of the lessons. This suggested that the idea developments demonstrated students' adequate attainment of problem solving through the lessons and was promoted by their understanding of the properties of plastics from scientific viewpoints.

[27P2Y-14] Issues in Using Art Works as Teaching Materials (*A0102*)

Hsin-Ying Chiang
University of Taipei, Taiwan

ABSTRACT The main purpose of this research is to explore the curriculum image of aesthetic education. The research employed participant observation, interview, and document analysis from 6th grade' teaching and learning in an elementary school in Taipei County. By the way of museum school collaboration, this curriculum using art exhibitions as teaching material to arouse students' aesthetic experience. In this research, teachers combine different learning areas, and construct an art exhibition environments, making students be exposed in an aesthetic surroundings. Through studying, experiencing, and making cultural actions, student can get a whole (aesthetic) experience. At last, according this research, curriculum which using art exhibitions as teaching material shows characteristics of aesthetic emerging, play and cultural actions. [Draft]

[27P2Y-16] Talent Characteristics of Science and Non-Science High School Students in Japan (*A0424*)

Sora Hashimoto* and Manabu Sumida+
Matsuyama Higashi Senior High School* and Ehime University+, Japan

ABSTRACT The purpose of this study was to investigate the domain specificity of talent in high school students and its influence on their course selection. The original 61 survey items were developed to examine the following talent characteristics: (1) students' interests (e.g. a preference for counting, for classifying things, and a hunger for excitement); (2) their abilities (e.g. creating unique ideas, being extremely good at reading and calculating); (3) their way of thinking (e.g. not being able to assert their own opinions, rarely having prejudices); (4) their personality (e.g. having a strong sense of friendship, disliking violence). The subjects were 196 grade 11 science students and 151 grade 11 humanities students of a public high school in an urban area. The results of a factor analysis revealed the following four factors: (1) challenging, (2) logical, (3) friendship, and (4) careful. A comparison between the two student groups showed that the science students had a higher level of the 'logical' characteristic than the humanities students. Both groups showed a high level of the 'friendship' characteristic, but were also 'careful' (e.g. they rated high for the items such as 'not being able to assert their own opinions', 'extremely conscious of others' evaluation of them'). We then analysed their answers to the open-ended question about what is important to achieve success using a text-mining method. After mapping the answers of students from both groups, it was found that 'study' and 'efforts' were the main keywords in their answers. 'Communication skills' was also extracted as a common keyword. There were some domain specific characteristics of talent in high school students. 'Science subjects', 'creativity', and 'imagination' were common in the answers of science students, and 'English' and 'self-expression skills' were common in the answers of humanities students.

[27P2Y-17] Analysis on the Inquiry Activities in Physics Textbooks of Korea through the Crosscutting Concept 'Patterns' of Scientific Practices (*A0544*)

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ABSTRACT In a recent science education, inquiry education and integrated education has been emphasized, the goal of science education is seeking not only a simple acquisition of knowledge, but also a deep understanding. United States National Research Council (NRC, 2012) presented the three dimension structure according to the societal change: the science and engineering practices, core ideas, cross-cutting concepts. Four Core Ideas in the physical sciences are PS1: Matter and Its Interactions, PS2: Motility and stability: Forces and Interactions, PS3: Energy, and PS4: Waves and Their Applications in Technologies for Information Transfer. The eight practices described in scientists and engineers: 1. Asking questions and defining problems, 2. Developing and using models, 3. Planning and carrying out Investigation, 4. Analyzing and interpreting data, 5. Using mathematics and computational thinking, 6. Constructing explanations and designing solutions, 7. Engaging in argument from evidence, 8. Obtaining, evaluating, and communicating information. Seven crosscutting concepts are defined as: 1. Patterns, 2. Cause and effect, 3. Scale, proportion, and quantity, 4. Systems and system models, 5. Energy and matter, 6. Structure and function, 7. stability and change. The purpose of this study was to examine the characteristics of inquiry activities through the patterns of scientific practices proposed in

middle school and high school physics textbooks based on the 2009 modified National Curriculum in Korea. The inquiry activities were analyzed using the patterns of scientific practices developed a classification and introduced in the Science Education Framework (NRC, 2012). The results showed that the inquiry activities in the middle school textbooks emphasized two scientific practices among the eight ones: 'Developing and using models' and 'Analyzing and interpreting data'. The high school textbooks emphasized two practices from eight ones: 'Developing and using models' and 'Constructing explanations and designing solutions'. We found that there were big differences according to the textbooks, parts, sections and grades, for the patterns of scientific practices. That is, the diverse learning inquiry activities were not sufficient.

[27P2Y-19] The Effect of Problem-Based Learning on Concept Change of Combustion (*A0263*)

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ABSTRACT This study explored the effect of Problem-Based Learning (PBL) on sixth-grade students' concept change of combustion by quasi-experimental design. Two classes of sixth-grade students from an elementary school in Taoyuan, Taiwan participated in the study. Thirty-three students of the experimental group were taught using PBL and thirty-two students of the control group by regular lecture instruction for five weeks. The two-tier Combustion Misconceptions Diagnostic Instrument (CMDI) was used as pre-test, post-test and delayed test instrument with semi-structured interviews for experimental and control groups. CMDI contained seven dimensions such as combustion properties, combustible, comburent, combustion point, combustion product, mass conservation after combustion and extinguishing. The results showed that the overall effects of PBL on students' post-test scores and delayed test scores of CMDI were significantly better than those of regular lecture instruction. Combined with qualitative analysis through semi-structured interviews and portfolios, presenting results with experiments could improve students' concept learning and concept retention of combustion. The effect of PBL promoted students' concept change of combustion towards scientific concepts. The students had more unstable alternative concepts with regular lecture instruction. Such findings suggested that PBL had a positive impact on the concept change of combustion for sixth-grade students.

[27P2Y-20] Analysis of Awareness of Teachers for Core Competencies (*A0068*)

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ABSTRACT The purposes of this study were getting the information for successful application to the national curriculum and students' core competencies enhancement, through investigation about competencies discussed in 2015revision national curriculum development process and analysis about perception of elementary school teachers in study. For these purposes of the study, there are the research methods of two types. One is the literature review, and the other is the perception investigation. In the literature review, workshop materials(Ministry of Education, 2015c), Press release(Ministry of Education, 2015b), and Elementary science Teacher's guidebook of 2009revision science curriculum(Ministry of Education, 2015a) were analysed to obtain information about composition of teachers' perception questions. The perception research investigated 157 elementary school teachers' perception through questionnaire. The results were as follows: In overall analysis result, communication skill (221points) is considered to be the most important. Thinking Ability (101points) what has been important traditionally is the middle of the rankings (5th place). Elementary school teachers tend to think that a competency is specific to a subject in overall analysis. From this point of view, additional analysis was investigated and those analytical range was limited to science. In scientific competencies analysis, Creative/Scientific Problem-Solving Ability (n=52) is the most important in science. The second place was Scientific Creativity-Convergence Thinking Ability, and Community Skill was ranked in the 3rd place that was the 1st in overall. Teachers thought that the enhancing of the Inquiry Performance Ability was highlighted in current science class. On Their perception, inquiry model is the most effective in enhancing of Scientific Thinking and the Inquiry Performance Ability, and STS instruction model is the second off best. Elementary school teachers thought that PBL learning model is the most effective in Scientific Thinking and experimental inquiry model is in the Inquiry Performance Ability.

[27P2Y-21] Analysis of the Elementary Teachers' Perception on the Change of 'Making a Fossil Model' Activity included in Elementary Science Textbooks during Four-Time- Curriculum Revisions in Korea (*A0395*)

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ABSTRACT Korean national science curriculum has been majorly revised and reformed four times since 1996. It included 6th, 7th , 2007 and 2009 Revised Curriculum. During the past revisions of curriculum, 'Making a fossil model' Activity has been included in elementary science textbooks. There have been changes including materials and approaches used in the activity. This study analyzed the elementary teachers' perception on such changes of 'Making a fossil model' activity. Questionnaires were developed for analyzing teachers' perception and administered to 77 elementary school teachers in Korea (Seoul, Gyeonggi and Incheon province). Changes of the activity during four-time-curriculum revisions perceived by elementary school teachers are as follows: the fossil model was made of clay and leaf in 6th curriculum and it was made of clay, shell, and pinecone in 7th curriculum. The teaching materials of 'making a fossil model' activities in 2007 revised curriculum returned to the same format in the 6th curriculum. The new material, alginate, was newly used in making the fossil model in 2009 revised curriculum. While the elementary teachers figured out well the advantages and limits of materials used in the fossil model

activity introduced in each different textbook through curriculum revisions, they have little understanding about changes and differentiation regarding fossil generation process, such as mold fossil, cast fossil, and trace fossil. Based on the results of this study, we suggested a professional development of the elementary teachers focusing on adaptation process of newly revised curriculum for better teaching practice.

[27P2Y-23] Thought of Mathematical Model in the Application of "Amount of Substance" in the Concept Teaching of Chemistry of Senior High School (*A0617*)

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ABSTRACT It is helpful for the transition of the abstract concept by applying mathematical model thought into the teaching of the chemical concept, which improving teaching efficiency. In the teaching of the concept of "amount of substance", the difficulty is to solve the relationship between the quality of the macroscopical substance that can be weighed and the number of microscopic particles. We need to build an aggregation. The international standard uses the number of carbon atoms of 0.012kg for reference to find the number of the microscopic particles according to (represents the quality of macroscopical substance, represents the quality of the substance collection, NA represents the number of particles of the collection). But in the process of the actual concept teaching, many teachers create situations by counting ways in our daily life for students, such as counting paper clips, coins, and so on. They confuse the concept of measuring and counting, which is bad for students to realize the concept changing. There are such prototype problems in real life. For example, the banks need to get the total value of the large numbers of RMB one-yuan coins(total quality denoted as) quickly. It also needs the thought of aggregation. Firstly, we measured a certain number of coins denoted as as a collection, and weighed its quality denoted as , then calculated the total value of the coins by using the mathematical model of , thus found the total value of the coins. When solving the practical problem, we found that the total quality of the large numbers of coins can be the analogy with the quality of macroscopical substance, the quality of a certain number of coins can be the analogy with the quality of the substance aggregation, the number of the coins we chose as a collection can be the analogy with the number of particles of the collection. Therefore, teachers can build a scaffold for students by the method of solving the problem in the teaching process. Through the method of using the thought of aggregation to solve the practical problems, which had an analogy to the construction of the concept of amount of substance. It helped the students to realize the transition of the concept. Thus the concept learning of amount of substance which was a bad problem was turned into a high quality problem, and it conformed to constructivism of scaffolding instruction model. Practice shows that, only when teachers distinguish the real problem with the unreal problem of the learning of amount of substance and choose the right mathematical model as analogy, can students achieve effective learning of the concept.

[27P2Y-24] A Framework for Automatic Detection of Attention in MOOC using Eye Tracking and Facial Expression (*A0228*)

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ABSTRACT In a real-world classroom, a teacher easily captures the attention state of students and accordingly adjust the speed and contents of lecture. This automatic adjustment refocuses students' interest and engagement, making the class efficiently. However, current MOOC (Massive Open Online Courses) platforms do not support attention recognition and miss the adaptive interaction and presentation of videos. To address this issue, we propose a framework for automatically detecting and analyzing learners' attention when they are watching videos. Eye movements have been proven to have correlation with attention states and interest area, which are used in areas of human-computer interaction, learning systems, and car and pilot driving. For example, Mello et al. (2012) proposed an intelligent tutoring system using eye tracking techniques to track students' attention states and then to refocus them by recommending intelligent interface with mobile dialogues. Results showed that this method improves learning and motivation. However, the pupil dilates more sensitively to light than information. The eye detection is easy to be affected by environment noises. Facial expression also reacts people's attention, like boring, interest, and happy, etc. Thus, our work is based on a combination of eye tracking and facial expression techniques to improve the recognition, leveraging Microsoft Kinect 2.0 depth camera to detect and measure features. In this paper, we first introduce a framework for detecting learner's attention in video learning, then present the design of an adaptive interface driven by this attention tracking framework, including the interactive meta-elements, properties and learning paths.

[27P2Y-25] The Learning Outcomes Exploration of English Teaching with Science Picture Books (*A0426*)

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ABSTRACT The purpose of this study was to investigate elementary students' science and English learning outcomes with popular English science picture books about light. A case study approach was adopted and three case students (one fifth grade high achiever in science, Amy; one sixth grade high achiever in science, Betty and one sixth grade low achiever in science, Chris, all pseudonym for ethical consideration) were invited in the exploratory study. The focused conceptions of light in this study (linearity and reflection) were both taught in their fourth grades. Although the instructional language in the regular science classroom in Taiwan is mandarin, the language used for instruction in this study was English and the teaching sequences included: (1) Recite & Recall, (2) Observation, (3) Sentences making (4) Explanation, and (5) Story finishing (i.e., ROSES strategy). Data collected in this study included videotaping of English teaching procedures,

assessment of light conceptions, students' sentences making for six-case caricature, students' sentences making for science picture book and the reflection journals of English teacher. The findings indicates that the abstract conceptions of light was difficult to understand for both fifth and sixth graders of high achiever in science even after their related school learning experiences; additionally, some common misconceptions of light were also found in their sentences making or explanations for science picture books. Furthermore, it seems that the students with low achievement in science cannot apply the conceptions of light to the sentences making for picture book even the conceptions had just been shown in the previous pages in the picture book. Finally, it is clear to see the sixth grader with high achievement in science tended to apply the conceptions of light and prior knowledge to sentences making and the post-test of student's English story finishing performance was found to be advanced after the English teacher's guided ROSES strategy interventions.

[27P2Y-26] Exploring Topic-specific PCK Progression for Elementary Teachers Instruction of Astronomy: Focusing on the Topic of Planet Size and Distance in Solar System (*A0145*)

Kiyoung Lee[1]*, Young-Shin Park[2+], Seungho Maeng[3], Jeong-A Lee[4], Hyunseok Oh[5], and Hyungsoo Kim[6]

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ABSTRACT Understanding the progression of teachers' PCK is essential in developing educational materials fostering teachers' expertise. That is, understanding of how teachers' instruction is changing can make it predictable what kind of educational materials is supportive or appropriate. To identify the development of PCK over time, learning progression (LP) can be utilized as a conceptual framework. LP is described as the sophisticated way of thinking about a topic that can follow one another as children learn and investigate a topic over time (NRC, 2007). The progression of teacher PCK can be also illustrated as the hypothetical pathway from novice to expert like LP. On the basis of LP mentioned in this study, we explored elementary teachers' PCK progression on specific topic of astronomy; planet size and distance in solar system. Eight elementary teachers at 5th grade participated in this study. We observed participating teachers' astronomy classes with same topic. In order to document topic-specific PCK of participating teachers, we developed an analytic protocol consisting of four categories; knowledge of curriculum, knowledge of teaching strategies, knowledge of assessment, and astronomical thinking practice. In addition, we monitored the change of four participating teachers' PCK for two years in order to validate the evidences of the PCK progression. Participating teachers in this study took some intervention by attending four-week pre-meeting with the researchers to profile an adaptive instruction. Through this research, we profiles four and five different levels of the PCK progressions in three knowledge components (curriculum, teaching strategies, student assessment) and one astronomical thinking practice (systems thinking), respectively. Participating teachers demonstrated various levels and pathways in each component of PCK. This study released the empirical evidences in fostering instructional scaffolding, which is appropriate to the level of PCK of science teachers on specific topic.

[27P2Y-27] The Effect of Authentic Learning in Elementary Science Classes: A Case Study in the Sixth-Grade Class of the Burning (*A0105*)

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ABSTRACT The science education in Japan mainly has two problems as follows: students at elementary and secondary school are poor at practical use of scientific knowledge in another context; students are scarcely conscious of that science learning bears relevance to their own daily life. To address these problems, we applied the concept of authentic learning to elementary science classes. The purpose of this study was to demonstrate the effect of authentic learning in elementary science classes. In order to achieve the purpose, we reviewed preceding studies on authentic learning and identified a framework to design science classes. The identified framework includes several aspects: Relevance to the real world, Practical use of scientific knowledge or skill, Acquisition of the learning contents, Various resources, Collaboration and Authentic assessment. Then the classes based on the framework were conducted for elementary school students (6th grade) on study of "burning." Further, to verify learning effects, evaluation test (Survey1) and questionnaire survey (Survey2) were conducted. The survey1 contains the typical test and the test for use of knowledge. Then we compared the experimental group with the control group. As a result, there was a significant difference in both of tests. In the survey2, we conducted the before-and-after survey with the questionnaire about the consciousness of science learning, which indicated significant differences in the items about the usefulness of science learning. As results of these surveys, the following two points were found: 1. The understanding of scientific knowledge was enriched through the authentic learning in science classes. 2. The authentic learning in science classes improved the affect about science learning.

[27P2Y-28] Utilizing Project-based Instruction to Promote Students' Information Technology Learning (*A0433*)

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ABSTRACT The major purpose of this study was to investigate the learning outcome of students' information technology learning by utilizing project-based instruction. Both quantitative and qualitative methods were used in this study. There were 24 senior college students participated in this study. The instructional strategy used in this study was project-based instruction. This study searched both quantitative and qualitative data as the sources for the analyses. The research instrument was used in this study was a course satisfaction survey which was a 5-point Likert-type scale. The results were undergone by frequency and mean analysis. The findings of this study include (1) the outcomes of students' feedback on the course learning were highly satisfied; (2) the outcomes of students' final projects indicate that students did pretty well on their project; (3) students' feedbacks also show that they favored in doing project-based learning. Therefore, it can be

concluded that using project-based instruction did improve college seniors in their information technology learning. [Draft]

[27P2Y-29] Teaching Mathematics to K-12 Students Using Artifacts from Museo De La Salle (*A0269*)

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ABSTRACT The artifacts found in Museo De La Salle were explored to identify whether these could serve as manipulatives for teaching Mathematical concepts to K-12 students particularly from Grades 7 to Grade 10. A survey and key informant interviews were conducted among seven (7) experienced Math teachers in order to explore the mathematical concepts that are observable in the 100 randomly selected artifacts. The teachers were also queried on how these Mathematical concepts can be learned and explored by the students. The study found that Geometry, Patterns and Algebra and Measurement were the main concepts that can be learned from these artifacts. Results further revealed that these concepts can be learned through visual approach, classification, measurement and as concrete exemplars for real-life situational problems. Insights from these results were drawn to develop activities in teaching mathematics to K-12 students. The study also emphasizes that museums are potential resources for the teaching and learning of Mathematics among K-12 students contributing to promote awareness, preservation, and appreciation of the arts and culture.

[27P2Y-30] Exploring the Change of Understandings and Practices of Astronomical Thinking through PCK: With the Content of Solar System and Earth Motion (*A0514*)

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1. Chonnam National University, 2. Moonsan Elementary School, and 3. Chosun University, Korea

ABSTRACT The purpose of this study was to explore the change of understandings and practices of astronomical thinking which consists of system thinking and spatial thinking. The term of 'learning progression'(LP) is referring to the purposeful sequencing of teaching and learning expectations across multiple developmental stages, ages, and grade levels. The LP of specific topics in solar system with system thinking and earth motion with spatial thinking has been developed (Lee et al., 2013, 2014, 2015, 2016) at each grade level, 5th and 6th in Korea. The 'Teaching Profession (TP)' about these topics has been also developed with the frame of PCK on the basis of LP, describing how teachers can teach those topics depending on 4 different levels of each thinking practice. The each TP of thinking practice consists of descriptions of how teachers do practice to each solar system and earth motion. The participating two teachers in this study took the professional development program of LP and TP for two days and they implemented into their classes separately. Teacher, Song, at 5th grade level implemented the content of solar system of 6 periods (each period lasts 40 minutes) with system thinking practices which covered from the low (level 1) to the anticipated anchor level (level 4) while she was teaching the content of solar system. She preplanned the content of solar system with system thinking practices with the help of science educator who is one of researches who developed LP and TP frames on the basis of experimental data. Teacher Song tried to teach the following contents; In level 1(understand the component), Song provided chances for students to figure out the components (solar and planets) with their characteristics by checking prior knowledge and playing games which students were familiar with. In level 2(classify them into groups and relate them), Song provided chances for students to classify planets by their own developed conditions and to understand the Sun's importance in solar system. In level 3 (generalize the system), Teacher Song taught students of what patterns they could find out in the content of distance and size of planets each in the solar system through diverse of teaching and learning activities. In level 4(system modeling), she tried to combine all patterns to be representing one solar system. Teacher Song will provide her own experience of implementing new teaching strategies of LP and TP frame with the solar system content. She will describe the successful and struggling episodes through trial and errors in her understandings and practices of LP and TP in her teaching solar system with the system thinking practice. This study will provide two different episodes by teacher Song (female) at 5th grade level and Son (male) at 6th grade level by action researches. This study suggests the implication in teacher education and curriculum development.

Poster 3X (28th, 11:30-12:50)

[28P3X-1] WeMAKE: Science & Technology Learning Platform (*A0519*)

Young A Lim[1], Seonna Lee[2], Dongseong Kang[3], Jongbo Kim[4], SeongHun Kim[5], SangHun Lim[6], Mira Yu[7], Jaekwon Kim[8], and Youngmin Kim[9]

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ABSTRACT Modern society is changing over to a small self-sufficiency using a 3D printer and open source materials from a mass production economy. In Korea 'Creation Economy' policy and the Convergence Education (STEAM) curriculum have been introduced since 2010. Lately, 'Creating economic innovation center' and ' Infinite imagination lab' have been installed national-widely and try to follow up on the new economic system and educational paradigm. This trend has the similar philosophical context with 'MAKER movement' which was born in west-America in 2006. 'WeMAKE', teacher's community originated in Ulsan 2014, have developed and conducted 'WeMAKE' science & technology learning camp program which aims the students to experience 'DIY(Do It Yourself)' activities. Elementary, middle, and high-school students who are interested in making new technology based products completed a five week's student-initiative learning course. Main themes of 'WeMAKE' are Media-Art, Robotics, Drone and Android App programming. Learning model is consist of 'Hacking(Reverse engineering)', 'Hardware design', 'Software design' and 'Redesign'. In the process of Making electronics-based products, they have confronted a lot of problems which needs metacognition. Students have to

overcome these difficulties by themselves. Therefore, this Learning model strengths student's design potential and make them setup a scaffold to be a member of self supporting economy in the future. During twice camps, summer and Autumn, primarily consisting of offline courses showed several problems at the point of time and space, cost-effectiveness, learning efficiency. Finally, to improve this problem, we are suggesting the alternative of off-line and online duality learning model, so called "WeMAKE platform". [Draft]

[28P3X-2] The Studies of Developing STEM-teaching Materials on Urban Heavy Rain in Taiwan Elementary Schools (*A0480*)

Chien-Kuo Ku* and Heng-Chi Chou
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ABSTRACT Global warming and climate change caused the heavy rains will continue to expand in Urban. At present, schools in Taiwan have not provided any courses related to STEM (Science, Technology, Engineering, Mathematics) on Urban Heavy Rain. In order to promote STEM education in Elementary Schools, related supplementary teaching materials are developed. The study is focus on three goals. The first goal is knowing teachers 'views and students' view on Urban Heavy Rain of STEM The second goal is designing science activity after the interview with teachers and students. We used the "ADDIE" teaching-design program to develop teaching material of urban heavy rain and the students' learning effects after applying the method. The developing process of teaching material could be conclude in five steps, which was "Analysis", "Design", "Development", "Implement", and also, "Evaluation". The final goal of the research is realizing children's concept of the STEM built or not in the science activity. The research tools are self-edited by the researcher, which include: the interview of teachers' teaching demand, student's acknowledgement of the layout and content of heavy rain, and the achievement scale of students' learning achievement of heavy rain teaching, The teaching material is designed for 24 classes, and the participants are grade-six students. The research used purposive sampling to find 24 students in New Taipei City to be the object of study. During the experimental teaching, the researcher collected the information by the recording, the teaching diary, the interview, and the file of learning procedure to conduct the quantitative analysis and induction, as well as the heavy rain and urban drainage test of quantitative study assisted the research to illustrate. The research results as following : the teachers' view that Schools focus on academic performance in term of entrance examination scores and suggest to integrate the traditional subject matters such as biology, chemistry, earth sciences, physics, and technology into one major field of study. The intregration in STEM curriculum that teachers combine the element of STEM with Science and Technology, Mathematic, Social Studies, and Integrative Activities. In science, The students can understand the heavy rain reason and disaster of heavy rain in Urban. In technology, Students learned the drainage methods. In engineering, Students knew the drainage system of Urban and designed the school's drainage system. In mathematics, students could calculation rainfall and flow of water. After teaching, students are seen improvements related to "science principal of heavy rain", "drainage methods", and "designed drainage system" from Pre-test accuracy (52.3%) and Post-test Accuracy (76.1%). The expectation that teachers adopt the cooperative learning and add more hand-on activity to evaluate in multiple methods. The improvement of cognition about the element of STEM is caused by the teaching of STEM curriculum. The ability of independent thinking and problem solving was prompted by STEM curriculum. Finally, the suggestion of this research is that the researcher who is interested in STEM curriculum can conduct the experiment on different grade, and surburban area.

[28P3X-3] Vargula Hilgendorfii: As One of the Wonderful Bio-STEM Materials (*A0569*)

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ABSTRACT According to the Course of Study for high school biology, some experimental learning materials are desired as students can explore topics as they like in order to develop scientific thoughts and their expressions. In high school biology classes, students are interested in the topic of '' cells and molecules'' , because this topic has been intensely investigated recently. It is hard to visualize molecules such as DNA, proteins and enzyme because their size is too small to see even though we use microscopes. Therefore, there are fewer learning materials in biology classes in this area. In this study, we found that Vargula hilgendorfii was one of the best experimental learning materials for '' cells and molecules'' especially '' enzymology'' . By grinding Vargula hilgendorfii, luciferase and luciferin react and produce a beautiful blue light. Students can easily understand that the reaction is proceeding and it is easy to imagine the molecules by the intensity of the light. Also we found a new interesting result about the optimum temperature of the luciferase at 4℃. In pharmaceutical companies, the luciferase of Vargula hilgendorfii is one of the industrial tools used for the screening of the new drugs. Vargula hilgendorfii is a hopeful experimental learning material that shows students the meaning of studying science and it could be one of the wonderful bio-STEM materials used in classes because of its usefulness in greater society.

[28P3X-4] International Comparative Study on Exhibits Related to Astronomy: By Focusing on Characteristics and Science Curriculum Reflected in Exhibits (*A0201*)

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Seoul National University, Korea

ABSTRACT For students, astronomy is not only interesting but also difficult to learn. However, there is a limit to learn astronomy in school science setting since the scale of astronomy is vast. Fortunately, science museum as an informal learning institute can be helpful to overcome this limitation. Experiences in science museum provide something that any descriptions or illustrations cannot give. Therefore, there is no doubt that these experiences are precious both to teachers and students. For these reasons, the purpose of this study is to investigate characteristics of exhibitions related to astronomy and how much the exhibitions of astronomy museums reflect the contents and objectives of current science curricula. In this study, we selected some of the world-class science museum and

famous museums in Korea, and analyzed characteristics of their astronomy exhibition. We analyze these characteristics in the aspects of exhibition technology & media, presentation method and types of activities. Also, this study tried to figure out how content of exhibitions are connected to school science curriculum. The results of this study are summarized as follows: First, interactive and hands-on exhibits led the more active participation of the audience. It implies that educational effects can vary according to the display method. Second, the astronomy exhibits reflect most of the learning elements of science curricula concerned with astronomy. This result indicates that the astronomy museum as an informal education institute is comparatively well connected to science education. The results of this study can provide the basic data for presenting the desired direction of exhibition characteristics and contents.

[28P3X-5] Evaluation of the "Let's Excavate Fossils" Workshop Conducted at Elementary Schools (*A0107*)

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ABSTRACT The Gamagori Museum of Earth, Life and the Sea has performed various activities for the purpose of strengthening cooperation with schools, such as a study tour program including science workshops, visiting lectures and teacher training. Additionally, our museum has developed teaching materials for science education, thereby increasing the range of the museum's activities and promoting it as a place for teacher training and other school projects. Our museum has developed a new fossil excavation method, which involves dipping rocks with fossils into water in order to crack them more easily. This activity was named "Let's Excavate Fossils". In this study, the "Let's Excavate Fossils" workshop was conducted at four elementary schools and the pupils' response was then evaluated. Sixth grade pupils participated at all four schools. Following each class, pupils were asked to evaluate the teaching materials by completing a questionnaire. Pupils were surveyed as to whether (I) The fossil excavation class was interesting (II) They were now more interested in fossils than before (III) They would like to study further by themselves. There were 4 ranks of answers: 'I very much agree' (score 3); 'I agree' (score 2); 'I agree a little' (score 1); 'I don't agree' (score 0). In addition, participants were asked to freely describe their impression of the classes. A total of 246 pupils completed the questionnaire. The average scores for Questions I, II and III were 2.7, 2.3 and 1.7, respectively. As for Question I, more than 70 % of participants selected 'I very much agree', and approximately 20 % selected 'I agree'. For Question II, 'I very much agree' and 'I agree' altogether obtained approximately 80 % of participants. It was considered that most of the pupils were satisfied because they were able to experience fossil excavation first-hand, which enhanced their interest. Although 28 of participants (11.4 %) answered 'I don't agree' in Question III, it was clear that the remaining 218 (88.6 %) participants were stimulated to do further study of fossils. Some impressions of the participants were as follows: 'I had a good time because I have never excavated a fossil before. I would like to do it again.'; 'I was excited to excavate fossils.' and 'It was a lot of fun and I became more interested in fossils. I want to learn more by reading books and visiting museums.'. According to the results of the survey, most of participants learned with pleasure and became more interested in fossils than before. Therefore, it can be concluded that the developed teaching materials were effective in enhancing pupils' motivation.

[28P3X-6] Using Plastic Bottles as Reaction Vessels To Explore the Gas Chemistry of Old Submarine Technologies (*A0115*)

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ABSTRACT A method to introduce the underlying gas chemistry of old (non-nuclear) submarine technologies has been developed using plastic bottles. This method has been designed to be performed in a high-school extracurricular class in order to enhance the students' interdisciplinary understanding of chemistry. Plastic bottles (representing old submarines) are used as reaction vessels. The following three gas chemistry experiments are performed in the plastic bottles: (1) a CO_2 absorption reaction using soda lime (a mixture of $Ca(OH)_2$ and NaOH); this reaction is similar to the one that occurs in the air filter canister used in anesthetic facemasks, (2) a Cl_2 and H_2 evolution reaction via electrolysis of saltwater; this reaction highlights the accidental generation of gases by lead batteries on board submarines, and (3) a catalytic H_2O_2 decomposition similar to that used in a submarine propulsion system, e.g., the Walter engine system. The abovementioned experiments are common in high school chemistry textbooks and have been integrated into this method, which provides students with an opportunity to relate textbook chemistry with the real world. [Draft]

[28P3X-7] Educational Effects of Science Camp on Gifted Students (*A0582*)

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ABSTRACT The purpose of this study is to examine the educational effects of three days science camp on the gifted students. Science camp is often regarded as exciting informal education and it gives students the opportunity to enjoy science through hands-on activities, interactive experiences with mentors in a fun and supportive environment. The summer camp in this study is a three days science camp managed by gifted center at a college, and is offered for youth in Grades 5 to 8 who are identified as gifted learners at their schools. In this camp a broad range of curriculum is covered focusing on different areas of science, engineering, and technology. Science career mentoring is also offered by mentors who are college students majoring in science and technology. Pre- and post-camp surveys on self-esteem scale, self-regulated learning scale and attitude toward science are administered on the first and last day of the camp. Grade and gender differences of camp effects on these scales will be reported using SPSS. The findings on the educational effects of the science camp will be effective indicators by suggesting the best practices and considerations on science camps for

gifted students. [Draft]

[28P3X-8] Exploring Science Communication Displayed by Exhibit Media and Suggesting its Development Direction in Science Education: The Case of Nuclear Radiation (*A0268*)

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ABSTRACT The purpose of this research was to explore the science communication in exhibit media of science museum with the theme of nuclear radiation, which is one of global issues which citizen should know enough to make decision of its right and wrong to have reasonable understandings of it. The research team defined science communication as the tool of communicating concept, interest, enjoyment, nature of science, awareness, and opinion, 6 components of science communication. In case of nuclear radiation, we expect citizen to understand nuclear radiation more than 'concept' about it. Citizen need to have clear understanding about nuclear radiation in different ways, positive as well as negative ones, which is very argumentative nowadays on globe. To build ideal 'understandings' of nuclear radiation, citizen need to experience more than 'knowledge'. For the purpose of fostering citizen's understandings of nuclear radiation, it is very essential to explore the current status quo of nuclear radiation education embedded in information hall which belongs to nuclear power plants in Korea. In this study, we conducted the study as follows. (1) We developed exhibit media analyzing frame to be used for analyzing the level and components of science communication in exhibit media (2) We employed this frame to explore science communication in the media of nuclear radiation exhibits of information hall. We collected the data from 4 different information halls in nuclear power plants. The results of our study were as follows. First, there were many expository panels and graphic panels focusing on just one-side explanation as a deficit model. On the other hand, there were few interactive media, fostering communication between visitors and exhibits as an engaging model. The most frequently dominating components of science communication were 'concept' and 'interest'. The exposing of other 4 components, 'enjoyment', 'awareness', 'opinion', and 'NOS', were pretty limited in exhibit media. We concluded that the exhibit media is not used appropriately to foster rich science communication as an engaging model which make visitors engage in exhibits. In case of science center in Japan, however, there were more interactive media than that of Korea, resulting in more 'opinion' and 'awareness'. Surely there were dominating frequencies in 'concept' and 'interest' in Japan case too like Korea case. We can imply that various type media must be studied in its own strength and weakness to promote the components of science communication and its level. What exhibit media we will use in the museum is the issue in science communication.

[28P3X-9] A Case Study of Teaching Nature of Science in Elementary School: Student Investigation about Japanese Scientists (*A0324*)

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ABSTRACT Introduction: Through many studies on nature of science (NOS), science educators recognize that teaching NOS is useful approach to understand science itself. For example, in Japan, Ogawa (1998) shows in detail that teaching NOS has the pedagogical value that we can consider science as a culture and that we can learn about intellectual assets of the human race together with social circumstances. However, in practices, there are few science lessons focusing on NOS, especially in elementary school. On the other hand, in England, the National Curriculum science has the content of study revealing the works of many scientists. Research question: The focus on this study is the following question: Can we teach the NOS in elementary school science? To answer this question, we conducted an empirical research. Method : First of all, we planned science lessons on Japanese scientists' works and their impact on our society. Next, we examined a teaching method how to teach such contents. The presenter had carried out 9 lessons in 4th grade of elementary school, and survey objectives were 63 students. In lessons, students investigated Japanese scientists and their work, and they engaged in making their classroom newspapers relating to representing scientists' work. After their making newspapers, they had an opportunity to discuss and exchange their thoughts on scientists and their work. We conducted questionnaires before and after lessons, and verified the effect by analyzing both data. Data: The average number of scientists that students could relate to scientists' work correctly increased from 0.26 to 4.80 between before and after lessons. And then, we surveyed about the relation between scientists and our society (e.g. Do you think that scientists' work are connected with our daily lives? ; Do you think that scientists' inventions and discoveries can change our future society?) on five-point Likert scale (1 = totally disagree; 5 = totally agree). Results by Wilcoxon signed-rank test indicated that medians of after the lessons were significantly higher than before the lessons ($Z=-4.900$, $p<.001$; $Z=-3.526$, $p<.001$). Therefore, through lessons, we could interpret that students came to perceive the relationship between scientists' work and society. Results and conclusion: Consequently, we found out that students could come to recognize scientists' work and their impact on our society, and also think that scientists' work can change our life style. We can conclude that it is possible for elementary students to recognize NOS through studying the relation between scientist's work and our society.

[28P3X-10] Development of a Class for Junior High School Students to Think about Biodiversity Conservation on the Theme of Introduced Genji Firefly from other Areas in Japan (*A0164*)

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ABSTRACT Current science textbooks used in Japanese junior high schools deal with contents about invasive species from foreign countries, however contents about domestic invasive species are lacking. So, there are few chances for students to know problems in relation to domestic invasive species. In this study, we developed a class activity where junior high school students think about

biodiversity conservation focusing on the case of Genji firefly (Luciola cruciata), which is one of the most serious problem among domestic invasion. In the 100-minute long classroom activity instructed by the first author, students learned the ecology of Genji fireflies, the status of their release activity in Japan, and different flashing patterns between Genji firefly population in Kanto region and one in Kansai region by watching an original movie material. After these instructions, students were asked what would happen to a local population of Genji fireflies as a result of releasing individuals with different flashing patterns into an environment where abundance of them was declining. We evaluated the effectiveness of this class by comparing students' answers to the questionnaires given before and after the class. Results of this suggest two findings. First, the students understood that releases of Genji firefly without consideration of their genotype lead to degenerate native population, and that maintenance of the habitats appropriate for their growing phases was effective for the conservation. Second, they realized that there is what they can do to reform or defend their local natural environments.

[28P3X-11] Making Experimental Kit of Fuel Cell towards Teaching Material (*A0539*)

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ABSTRACT Hydrogen fuel cell is becoming a familiar source of energy. We reported development of a package program with a series of experiments of fuel cell, which leads people to understand the energy concept and was practiced at a workshop for elementary school teachers. The program includes some chemical reactions, such as photosynthesis, combustion, electrolysis of water and its reverse reaction, which provide concept of fuel cell, and utilization of photo-energy as further development [1]. Recently, hydrogen fuel cell vehicles from some automobile company have been released. It is worthwhile developing an experimental kit, which can be used as a model of practically used fuel cell. In the school, it is common to perform electrolysis to produce hydrogen and oxygen first, and then, the fuel cell experiment is performed in the same cell. This may create misunderstandings, such as, 1) observing capacitor type discharge, and 2) the fuel cell as a secondly battery. Therefore, we have decided to make a fuel cell kit with hydrogen gas feed. The kit could be used as a teaching material for the experimental program previously developed. The program would help people to understand not only advanced technology but also the concept of fuel cell. In this paper, approach of making a kit using self-made proton exchange membrane will be presented.

[28P3X-12] Development of Science Teaching Materials in English and Teaching Practice at Overseas (*A0484*)

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ABSTRACT To develop university science major students' global view, it is necessary to encourage their intercultural skills and foreign language skill within science field. In Japan, although the government has been emphasizing English education at elementary school in the recent years, there are very few lessons using science as a topic in English. Therefore, this study seeks to develop science teaching materials in English and nurture the students' creative teaching skills within the global society. For this reasons, we have been promoting Overseas Teaching Project (OTP) at our university for the past six years. University students in pre-service courses (for both graduate and undergraduate) participate in OTP in EU as a selective intensive lecture which is organized by professors majoring in various subjects. Students form groups of three or four using co-teaching between subject teachers and English teachers. They work together for several months, and implement a science lesson for the children at the age of twelve in English in the EU. The children learn English as a foreign language using subject content (such as math, art, science). The authors, in particular, supported this project by developing practical experiments in physics to have children be aware of a science point of view. With the longitudinal collaborative learning, in both subjects (science) and English, teachers are able to promote their teaching skills in both fields, then produce synergy in achieving their goal. More importantly, the science teaching materials, are refined and adjusted to the practical classroom throughout the project. Taking these products as some examples, the "soap film", "faraday motor (unipolar motor)", "capacitor", "bouncy ball rocket (law of the conservation momentum)"and "magnetism" were successful lessons. For instance, "Soap film" is formed within a shaped wire framework with a minimum surface area, using the surface tension. Soap Film experiments struck students' interest in surface tension. The experiments were demonstrated for not only visually appealing but also eliciting students' surprise to what extent the outcomes contradicted their predictions. The paper clip motor is one of the teaching materials for elementary and junior high schools in Japan. It is not easy to make them. However, even elementary school students were able to make a "faraday motor" easily. Students used soft and colorful aluminum wires instead of copper wires. These motors were simple and beautiful in order for the teaching materials to attract students' interest.

[28P3X-13] Investigating Trends of Gifted Education in Domestic and Foreign Countries through Social Network Analysis from 2010 to 2016 (*A0570*)

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ABSTRACT The purpose of this study was to analyze the trends in domestic and international gifted education in the last six years (2010-2015) by utilizing social network analysis methods. For papers of gifted education in Korea, two KCI (Korea Citation Index) rated journals, the 'Gifted/Talented Education' (The Korean Society for the Gifted/Talented) and 'Gifted and Talented Education' (The Korean Society for the Gifted and Talented) were selected and 457 pieces published in two journals were collected. The papers of 347 published in SSCI rated journals, 'The Gifted Child Quarterly,' 'Journal for the Education of the Gifted,' 'High Ability Studies' were selected. English keywords were extracted from 457 papers from Korean journals and 347 papers from foreign journals and the Social Network Analysis (SNA) way was utilized for

keyword frequency and central network analyses. It was appeared that the trends of paper keywords from domestic and foreign countries showed common keywords, 'academically gifted', 'science gifted', and 'gifted' as center keyword frequency, and keywords, 'achievement', 'identification', 'intelligence' appeared as the most frequent ones. For domestic papers, keywords, 'creativity', 'gifted education', and 'gifted education teacher' were the highest keywords while keywords, 'foreign countries', and 'student attitudes' were most frequent ones. For the analysis of papers from five journals as one group, it was found that keywords, 'identification', 'intelligence', and 'achievement' were the most important common ones and keywords, 'cognitive', 'motivation', and 'self-concept' were appeared as important keywords. The trend of gifted education in Korea seems to be different from ones of foreign countries, domestic papers of gifted education rarely included keywords of 'foreign examples', 'student attitudes', and 'gender differences.' Consequently, the trend of gifted education in Korea called for various research perspectives. [Draft]

[28P3X-14] The Effect of Concept Change Texts with Concept Mapping on the Understanding of Photosynthesis (*A0264*)

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ABSTRACT This study investigated the effect of Concept Change Texts with Concept Mapping strategy (CCTCM) on seventh graders' understanding of photosynthesis by quasi-experimental design. Two classes of seventh graders from a junior high school in Taoyuan, Taiwan participated in the study. Thirty-four students of the experimental group were taught using CCTCM and thirty-four students of the control group by regular lecture instruction for five weeks. CCTCM contained six processes such as training students' concept mapping, understanding students' misconceptions of photosynthesis, reading concept change texts with concept conflicts, discussing concept change texts to clarify misconceptions of photosynthesis, reviewing concept change texts and drawing concept maps, implementing photosynthesis concept diagnosis. The Biology Concept Diagnostic Instrument – Photosynthesis (BCDI-P) was used as pre-test, post-test and delayed test instrument for experimental and control groups. The results showed that the overall effects of CCTCM on students' post-test scores and delayed test scores of BCDI-P were significantly better than those of regular lecture instruction. The students' post-test scores of concept maps of the experimental group were better than their pre-test scores of concept maps. The findings suggested that CCTCM had a positive impact on the concept change of photosynthesis for seventh graders.

[28P3X-15] College Students' Moral Judgment about Socio-scientific Issues- An fMRI Study (*A0270*)

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ABSTRACT Socioscientific issues (SSIs) are included as major components of science curriculum in many countries. Moral dimension of decision-making about SSIs would contribute to clarify the interactions between emotional engagement and cognitive learning of learners. Individuals with Autism Spectrum Disorders (ASD) are usually diagnosed as lacking of emotional reciprocity and reported as being difficult to learn rules like morality (Hiraishi, 2011; Zalla, Barlassina, Buon, & Leboyer, 2011). In current mainstreaming policy of science education, students with ASD might encounter difficulties during learning SSIs related texts or learning activities. This study reports the comparisons between moral judgment of eleven male college students with a clinical diagnosis of ASD and fifteen age and IQ matched male volunteers with typical development and without a history of psychiatric or neurological disorders. Participants of both groups were individually scanned by a Siemens MAGNETOM Skyra 3T scanner at a Mind & Brain Imaging Center while making moral judgments on thirty-two SSIs examples in science textbooks. The time for making decisions by each participant was also recorded. The selected SSIs were phrased as sixty-six three-sentence scenarios (Kuperberg, Lakshmanan, Caplan, & Holcomb, 2006) with the first sentence states a fairly non-constraining context of an SSI-provoking event, the second and the third sentences address explicitly about the dilemmas of an SSI which evoking negative emotion. Equal number of scenarios as directly related conditions and non-directly related conditions for all participants to make moral judgments. Data analyses revealed that both groups spend similar time duration on both directly and non-directly related conditions scenarios. Nonetheless, the results of contrasting non-directly related conditions and directly related conditions between the two groups indicated that their brain differ significantly ($p < .001$) on activation at the right parahippocampal gyrus where Rankin et al. (2009) pointed out that the lobe may play a crucial role in identifying social context and detecting sarcasm. Furthermore, adding prompt in the three-sentence scenarios was effective in delaying making moral judgment in both groups. This study provides educational implications for preparing SSIs teaching materials.

[28P3X-16] Research on the Constituent Elements and Development Levels of Students' Ability of Scientific Experiment (*A0351*)

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ABSTRACT Scientific experiment is an important content of science curriculum, and it is also the major way for students to carry on the scientific inquiry. Therefore, promoting the development of students' scientific experimental ability is of great significance for improving students' scientific literacy. In this study, we theoretically elaborate the constituent elements and influence conditions of scientific experimental ability, and construct its static structure and dynamic development model. From the static perspective, scientific experimental ability is composed of three basic elements——experimental knowledge, experimental skills and experimental awareness. These three elements connect with each other, which maintains and promotes the smooth completion of laboratory activities. From the dynamic development perspective, scientific experimental ability is associated and develops

along with the specific practical activities. Based on the cognitive activity program of problem-solving in scientific experiment, we put forward the dynamic development model of scientific experiment ability, expound concrete tasks for each link during the process of experiment, elaborate how chemistry experimental knowledge, skills, and awareness interact with each other to promote the development of experimental ability, and raise the target level and the external performance of each experimental ability. Then, take the scientific experiments included in the Chinese Compulsory Education Science Curriculum Standards for example, we analyze the constituent elements and development levels of scientific experimental ability in each type of experiment, especially the material preparation experiment and the material properties experiment, and raise the goal requirements and specific suggestions to the experiment teaching. The conclusion provides specific guidance and advice to middle school scientific experiment teaching.

[28P3X-17] Fostering High School Students' Scientific Modeling through Model based Inquiry (*A0423*)

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ABSTRACT Model based inquiry is a lab-based strategy which affords students the opportunity to develop scientific modeling. This study aimed to investigate the effect of model based inquiry on students' scientific modeling performance of solid, liquid, and gas which is a significant content in high school science. The scientific modeling performance test was administered to 37 grade 11 students who studied in a chemistry class at a rural school in Thailand. All items of the test required them to express four elements of scientific modeling – drawing, core concept, representation, and labeling. Findings in this study present that the students significantly improved all components of scientific modeling. As a result, it could be concluded that model based inquiry could be served as an approach supporting students' scientific modeling performance.

[28P3X-18] Collaborative Innovation: A New Mode and Mechanism of In-service Teacher Education Training in Beijing Institute of Education (*A0299*)

Ying Zhou

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ABSTRACT Under the global science educational reform tide, teachers' education and professional development are more and more important. Thus, in-service teachers' education training faces new opportunities and challenges. As a public in-service teacher training base in Chinese capital, our group in Beijing Institute of Education has set up a new training mode-Collaborative Innovation (CI) since 2016 to increase the efficiency of teacher training. More than 3000 in-service teachers from 198 schools were involved in CI training programs. Collaborative Innovation (CI) differs from the other training class with the following differences: (1)Offering tailored courses for different schools based on investigation and analysis. (2) Introducing teachers' education in 198 projects schools, combining the teaching with practice. (3) Adjusting training plans with the current situation, in order to meet the requests of schools. Beijing Institute of education was founded in 1953, which had committed national training missions, especially the in-service teachers' training in fundamental education in Beijing. However, with the popularization, information and internationalization of fundamental education in China, the transformation of the teacher trainers' role has faced great challenges and conflicts. The traditional administration form and training thinking method have been shocked seriously. Our past training mode based on large-scale class was generally less targeted In CI mode of training, deep insight into the in-service teachers is needed to understand whether or not our trainings can meet teachers' real needs effectively. This study is aimed to show the characteristic of the CI mode, offer a variety of detailed and vivid first-hand teaching cases as the evidence for research. The dissertation has received the subsidies of the major project of Beijing Institute of Education. (NO. JYZD201505)

[28P3X-22] The Discussion on the Problems of Chinese Pre-service Chemistry Teachers in Inquiry-based Teaching (*A0621*)

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ABSTRACT In the implementation of new universal chinese curriculum reforms , chemistry courses standard of full-time in compulsory education (2014) and high school chemistry curriculum standards (2014) advocate that it is essential to develop the students' scientific inquiry abilities. However, teachers' inquiry-based instructions directly impact their students' experience and abilities on scientific inquiry. Compared with in-service teachers, the pre-service teachers do face greater challenges in teaching inquiry science. This study report on pre-service chemistry teachers' problems of inquiry-based teaching. The author selected 36 pre-service chemistry teachers from Chemistry Education Institution of Central China Normal University into 12 groups (they will go to high school for teaching practice in next semester). Every group randomly selected a fragment from textbook "Chemistry 1"and "Chemistry 2", which edited by Chinese People Education Press, to prepare for a 10 minutes inquiry-based instruction and showed their teachings in Demo Class. Through text analysis, video analysis and semi-structured interviews, we got four major problems on teaching inquiry as follows: (1) Not clear that which part of chemistry knowledge is more suitable and valuable for inquiry teaching. (2) Do not know how to construct a problem context for students to posting effective questions. (3) It's hard to coordinate the relationship between teachers' guidance and students' independence in science inquiry program and process. (4) Could not correctly grasp the depth of the inquiry during inquiry-based teaching process. In view of the above difficulties, the author analyzed the causes from their personal and environmental aspects, then offered some relevant suggestions based on the research.

[28P3X-23] Development of the Educational Program in Science based on Questioning Framework: Focusing on Interactive Activities in Relation to Natural Phenomena for Inducing Cognitive Conflicts (*A0057*)

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1. Kitauwa High School, Ehime, 2. Ehime University, 3. Hyogo University of Teacher Education, Japan

ABSTRACT The purpose of this study was to investigate the educational program in science based on questioning framework for inducing cognitive conflicts. Using "puzzling picture" effectively depends on the questions that the teacher asks. First, the teacher uses divergent questions to elicit various responses. After that, the teacher uses convergent questions to focus on science topics. The content of the experiment was to perform a description of the after-image effect. When one tries to observe the water droplets using a stroboscope, water droplets appear to fall, be stopped, or climb. The lesson pertaining to this educational program was administered to 96 in the 10th grade students to determine the effects of the questioning framework. The content of the survey-questionnaire and worksheet were analyzed by using quantitative manner. The following were the results of the study: 1) it is not just fun, it is also beneficial at learning principles of natural science; 2) through the use of "think-pair-share" worksheet describing the interaction with others, observation and experimental results, the results of reasons were to be easily observed; 3) using the prior knowledge, obtaining new knowledge from others, and formulating new questions.

[28P3X-24] Developing the Teaching Method for Nature of Science: Connecting Characteristics of Science and Decision Making (*A0080*)

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ABSTRACT A major obstacle in the teaching methods for Nature of Science (NOS) is the lack of understanding of NOS for the long term. This study devised a teaching method to solve this problem. Therefore, it stipulated that teaching methods should connect new knowledge about NOS to students' prior knowledge (Khishfe, 2015). Additionally, we focused on the characteristics of science, such as "theory ladenness of observation," "creativeness," and "tentativeness," and its relation to NOS. On devising the teaching method, we focused on 1) context of teaching, 2) way of teaching, and 3) method to connect (the new knowledge about NOS to students' prior knowledge). First, the context of teaching includes "integrated," which is related to the science content, and "nonintegrated," which is taught through a set of activities that specifically address NOS issues. We selected "nonintegrated" as it is more flexible of the two although the result obtained through both has a minimal difference (Khishfe & Lederman, 2006). Second, with respect to the way of teaching, we selected "the explicit and reflective approach" that is more effective compared with "the implicit approach" or "the historical approach" (Khishfe & Abd-El-Khalich, 2002). Third, regarding the method to connect, we determined the manner in which the characteristics of science were connected to the subject that enabled the students to make a decision scientifically (students' prior knowledge). This is because Yuge & Kawasaki (2015) find that understanding the characteristics of science positively influences scientific decision-making ability. Thus, this study's teaching method explains the characteristics of science through the "nonintegrated" and "the explicit and reflective" approaches. Subsequently, it elucidates on the connection between the characteristics of science and decision making. This teaching method was practiced in December 2015 for 165 junior high students in the third grade; furthermore, its effects were investigated. A questionnaire was used to measure the understanding of the characteristics of science laid down by Yuge & Kawasaki (2015) for inspecting the effects; we investigated the effects before practice, just after practice, and three months after practice. The results indicated that the score was higher before practice to just after practice, and the score decreased from just after practice to three months after practice. Therefore, we concluded that this teaching method would not enable the students to hold the understanding of the characteristics of science for the long term. As the reason, the high school entrance test might influence the investigation.

[28P3X-25] A Study of Designing Learning Environment to Develop Student Competency and Teaching Skills: Case of Japan (*A0365*)

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ABSTRACT In this study, we defined student competency as well as science teaching skill that should be development as the ability to construct and express a science concept through collaborative problem solving. In order to develop student competency and teaching skills, we designed a science lesson based on the framework that proposed of Taylor, Fraser & Fisher (1997). The framework are i) Personal Relevance, ii) Uncertainty, iii) Critical Voice, iv) Shared Control, and v) Student Negotiation. The lesson was a fourth grade science unit: "the volume of air change when heated". We qualitatively analyzed the activities of teacher and pupils in the class and pupils' writings on worksheet. Results indicated that: (1) Pupils solved the problem collaboratively. (2) Pupils expressed their own ideas as performance. And they developed their ideas during the process of learning. (3) The teacher assessed the pupils' thinking and provided feedback based on assessment. Our science lesson could foster the development of pupil's competency. The proposal of Taylor et al. (1997) was useful for designing the science lesson.

[28P3X-26] Effects of the Tutorials on Students' Understanding of Newton's Laws: An Investigation at a Japanese High School (*A0124*)

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ABSTRACT Acquiring physics concepts is not easy because some of them are counterintuitive. In order to get physics concepts across to students, various teaching methods have been developed and practiced so far. One of the major findings of these studies is that active learning environments are more effective than traditional passive lectures. First, in this study, to evaluate the effect of our traditional physics lectures at a Japanese high school, we conducted surveys on the Force Concept Inventory (FCI) for the first year students (the number of students, N=119) at the beginning and the end of a one-year introductory physics course in the academic year 2013. The average

correct answer rates were 27% and 42% for the pre-test and the post-one, respectively. The normalized gain was 0.20, which fell within a typical value of traditional lectures reported. Interestingly, we have found that the correct answer rates of Q.15 and Q.26, which are related to Newton's second and third laws, were significantly lower than those of the other questions: in the post-test, the average percentages of correct answer of Q.15 and Q.26 were 16% and 12 %, respectively. These results suggest a limitation of the traditional passive lectures and these several concepts in Newton's law are extremely difficult to be understood. To improve the percentage of correct answers for these questions, we introduced an active learning method into our traditional physics lectures. Though there are a variety of methods of active-learning, we selected Tutorials in Introductory Physics (Tutorials), because our classroom environment can be used without any modification. The Tutorials, which was developed by the Physics Education Group at the University of Washington, is a set of research-based instructional materials designed to supplement a standard introductory physics course of University. The purpose of this study is to investigate how the Tutorials developed in the United States work at a Japanese high school. In the academic years 2014 and 2015, we implemented the Tutorials in the first-year high school classes. We used the worksheets of Newton' s second and third laws in the Tutorials, which include the mechanics concepts being questioned in Q.15 and Q.26 of FCI. We translated the first two sections of the worksheets into Japanese. The Tutorial lessons were inserted in the traditional teaching class for two hours of class time, where the students tackled the worksheets and homework. The results of the post-test showed a significant improvement over the 2013 post-test: for Q15 and Q26, the average correct answer rates in 2014(N=112) were 35% and 21%, respectively, and those in 2015(N=124) were 37% and 25%, respectively. The difference of the correct answer rates between traditional lecture method (2013) and the active-learning method (2014, 2015) was statistically significant ($p<0.05$). The results suggest a positive effect of the Tutorials at a Japanese High School.

[28P3X-27] The Learning Achievement of University Students in Web-based Cooperative Learning Environment in Ecology Course (*A0199*)

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ABSTRACT This research explored the effectiveness of different formative assessment strategies on the university students' achievement and the effects of different self-efficacy students on their learning achievement in web-based cooperative learning environment of Ecology course. Quasi-experiments research design, the survey of the self-efficacy in web-based cooperative learning ecology, the Formative and Game Assessment Modules of the Web-based Assessment and Test Analyses (WATA) system, and the survey of the feelings in web-based cooperative learning ecology were employed. Thirty-seven students from the third year of biology department participated in this study. There were significant difference ($p<.01$) on the different self-efficacy of students. The post-test scores of low score set were significantly different from those of medium score set ($p<.05$) in the first phase. There were no significant differences among three score sets of the post-test scores in the second phase. The results of Web-based Formative Assessment Strategies Scale (WFASS) survey showed significant differences among the learners of the three different self-efficacy groups with "Provide with no Answer"($p<.05$), "Check Personal Answer History of Each Item"($p<.01$), "Ask Questions"($p<.05$) and "Qualifier Rewarded with Flash Animation"($p<.05$). The results of Web-based Game Assessment Strategies Scale (WGASS) survey showed significant differences among the learners of the three different self-efficacy groups with "Compare with Traditional Way of Test"($p<.01$), "The Differences of Attitude to Use The Different Ways of Tests"($p<.01$) and "Using the Gold Medal"($p<.05$). There were significant differences among the learners of the three different self-efficacy groups with " The Effectiveness of Using The Web-Based Cooperative Learning Environment"($p<.01$), "The Effectiveness of Discussion on the Platform"($p<.01$) and "The Effectiveness of Using Formative Assessment Module of the WATA system (FAM-WATA)"($p<.01$) in the second phase.

[28P3X-28] Investigating the Factors that Influence Chemistry Teachers' Implementation of 'Scientific Inquiry' Activities (*A0007*)

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ABSTRACT This paper aimed to explore the factors that influenced senior secondary school chemistry teachers' implementation of 'scientific inquiry' activities arranged in the textbook in China. The research paradigm adopted in this study can be classified as the interpretive approach whose primary goal is to elucidate and interpret the meaning-perspectives of chemistry teachers in their implementation of 'scientific inquiry' activities. The sampling strategy of 'maximum variation' was employed and five senior secondary school chemistry teachers in Nanjing, the capital of Jiangsu province in eastern China, participated in this study. Classroom observation and interview were used as research methods to collect the data. 'Grounded theory' was employed to analyze the data. The data analysis revealed that there were three factors that influenced teachers' implementation of 'scientific inquiry' activities, and these factors were pedagogical content knowledge (PCK), time constraint, and teaching resources. Based on these three factors, three suggestions were discussed in the last section of this paper. First, more interactions needs to be undertaken between textbook writers and chemistry teachers; second, when assigning teaching hours, school administrative staff should actively communicate with teachers so as to ensure that they have enough time to carry out inquiry activities; third, sufficient teaching resources (e.g., laboratories, laboratory technicians, and experiment equipment) should be provided to teachers. [Draft]

[28P3X-29] A Case Study of a High School Biology Teacher to Promote Students' Conceptual Understanding through the Scientific Explanation (*A0321*)

Jhuo-Syun Sie*+ and Shu-Fen Lin

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ABSTRACT Science language involving in scientific terminologies and conceptual relationship is a medium of communication among the scientist communities. It is obvious that learning to use this specialized conceptual language is important in reading, writing, problem-solving, and communicating scientific matter. The learners who lack of scientific terminology prior knowledge are like the beginners learning foreign language. In addition, some learners infer scientific terminology from their literal meaning, but a lot of misunderstanding could occur. Because scientific explanation in textbook is not based on students' prior knowledge or experience, learners would often misinterpret the content in textbooks. To help student understand the concepts or scientific terminology in textbooks, science teachers play a key role. Hence, the purposes of this study were to explore students' understanding of scientific terminology (including single words and compound words) in grade 10 biology textbooks before and after a teacher's instruction, and to analyze the process and types of scientific explanation applied by the teacher. A biology teacher with 20-year teaching experience and his students (N=38) participated in this study. Eight lessons of teaching contents in the units of human circulation, immunity, and reproduction were investigated. Data was collected through the copies of the three-unit textbooks, a concept test, class observation, and semi-structured interviews before and after the instruction. The analytical framework of scientific explanation types were based on the studies of Norris et al. (2005) and Dagher et al. (1992). The findings revealed that the textbook contains many scientific terminologies that students cannot understand. Before teaching, the quantity of compound words that students cannot understand was slightly higher than the quantity of single words. After teaching, the teacher explained about 70 percent of students' incomprehensible single words and compound words. He seemed to focus on more single words to explain than compound words. Five types of scientific explanations were often used by the teacher in study including descriptive, functional, practical, interpretive, and causal explanations. Descriptive and functional explanations were found to be the most beneficial to high, medium, and low achievers' understanding of concepts. Practical explanation was of little benefit to low achievers' understanding of concepts. Based on the findings of the study, some suggestions regarding teaching and compiling materials were proposed.

[28P3X-30] Nature of Science for All Science Teachers (*A0420*)

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ABSTRACT The research on Science Teaching as Lesson Study in Japan, Korea, Taiwan and Hong kong* was carried out, and the following two points are clarified. 1. The various teaching methods are observed, such as explaining and receptive learning, discovery and inductive learning and so on. 2. But strong empirical belief of teachers are observed in all classroom lessons. Despite of various way of teaching, the adequacy of ways of teaching are depended on the case, these are elementary or secondary schools, learning content and teaching materials which they can use. The teaching method is not important, the quality of learning of learner is important. The way of teaching has to be determined by learning content, useful teaching materials and equipments, actual situation of learners and teaching skill of present teacher. From the points of present learner, it is considered that the constructivist theory of learning which explains the learning as construction of concepts and/or conceptual exchanges, accords with the learning in real situation. On the other hand, the teachers are liable to consider that all learners observe as same facts which teachers observe. So, they consider that learners should understand by observed facts from observation and/or experiment, from the empiricism belief. The difference between the empirical teaching by teachers and the constructivist learning of learners, often brings the learning difficulties to present learners. The teaching and the learning have to be concordant, and the way of teaching have to be consistent with the learning of present learners. This is the responsibility of teachers. Realizing above mentioned, all teachers have to understand the following points of the Nature of Science (NOS). 1. Importance of the construction of theory as the linguistic activity and the theory-ladenness of observation. 2. The holistic view of the nature as mechanism for determination of theories for various interpretations of the facts. 3. The paradigm theory as models of teaching strategy of conceptual exchange. For these purpose, it is very important to introduce NOS education into teacher training. [Draft]

Poster 3Y (28th, 11:30-12:50)

[28P3Y-1] Developing Students' Scientific Literacy Using Reading and Writing Activities (*A0394*)

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ABSTRACT Scientific literacy refers to the ability to conduct scientific investigations and scientific explanations in a manner acceptable to actual scientists. Activities such as reading and writing scientific reports are similar to how scientific inquiry is generally cognitively processed, especially with regards to activities involving making predictions, constructing models, generating conclusions, and so on. This study proposed a course to develop high school students' scientific explanation capabilities through reading and writing of science texts. The course was intended for grade 10 students; it spanned 30 hours over two semesters (one hour per week). Reading materials included six articles that were mainly collected from Scientific American and included no revisions. All six reading sessions came with worksheets and class activities emphasizing sets of scientific reading strategies, such as graphical literacy, experiment design, and structure of scientific explanation. Each group of students was required to grow one plant, collect data related to the plant's growth, and make a poster in which logical explanations of the plant growth were needed. A total of 62 students (two classes) participated in the course. Data were collected from

pretests, posttests, worksheets, and their final projects. The course was videotaped, and students' group discussions were audiotaped. Significant improvements were found in their overall scores, as well as in their scientific explanations, textual comprehension, and ability to summarize. Mars in Motion was one article used in the course, in which the author described how scientists used collected data to propose and modify their explanation models regarding whether there was water on Mars. As the author's model explanations became more complex, more students had problems determining the data, inferences, and claims, as well as the logic that connected these three elements. This could have been due to defective comprehension such as using local evidence to make global explanations, or students may have mistaken evidence in different models. Since there can be several models of explanations in one science text, teachers are suggested to pay attention to students' comprehension of evidence or claim uses within or among different models.

[28P3Y-2] Development and Practice of "RIKADOKU" Program for Biological Education of the Early Year Children: Case Studies about "the Similarities and the Varieties of the Citrus Fruits" based on Japanese Culture (*A0352*)

Asami Ohnuki[1]*, Rumi Haraguchi[2], Yutaka Takigami[3], and Mikako Doi[4]

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ABSTRACT As we can find citrus tachibana in "Chronicles of Japan": one of the oldest official national histories of Japan, the citrus fruits are ingrained in Japanese Culture. In Japan, a varieties of citrus fruits are available all year round. In addition, there are the customs to eat "Mikan (satsuma orange)" and to take "Yuzu-Yu (the bath with citrus junos)" in winter. In this research, "RIKADOKU (science education using the books)" program for understanding the similarities and the varieties of the citrus fruits is developed based on those Japanese backgrounds. The observation of the real citrus fruits, reading aloud of the picture books, and the interchange with the nurses are included in this program. It consists of 2 parts: "the similarities and the varieties of the citrus fruits" and "the fructification process of the citrus fruits". In the former part, the picture book "MIKAN" were read aloud for remind of children's experiences. Then, they observed 16 kinds of citrus fruits to figure out their similarities and the varieties. After that, in the latter part, children learned the fructification process of satsuma through the observation of the inner structure. At the last part of this program, another picture book "The Secret of Satsuma" was used for enriching their understandings. The practice was held at 3 public nurseries in Tokyo. Through this practice, it was clarified that the children could figure out satsuma from a variety of the citrus fruits. However, several children mistook lime as kiwi, and citrus maxima as melon. Hence, they had not had the image of the difference between the citrus fruits and other fruits. For those children, the second book was efficient to notice the similarities of the various kinds of citrus fruits in different shape, size, and color. In Addition, this book enabled them to know unobservable concepts such as the annual fructification process of satsuma. As a result, it can be said that this program is fit to early year children having the basic concepts of biological taxonomy using their daily used words. [This work was supported by JSPS KAKENHI Grant Number JP16K12769.]

[28P3Y-3] Development of Training Design and Materials to Enhance the Mathematics Teachers Competencies (*A0011*)

Dolly Rose F. Temelo

West Visayas State University, The Philippines

ABSTRACT This quantitative research that utilized a quasi-experimental research, specifically, the one group pretest-posttest design aimed to determined the effectiveness of the developed training design and materials to enhance the mathematics teachers' competencies on the Enhanced K-12 Basic Education Curriculum. Eighteen Grade 7 mathematics teachers in the Division of Passi City, Iloilo who attended the Department of Education Regional Mass Training on the Enhanced K-12 Basic Education Curriculum served as respondents of the study. The posttest result based on the competency rating sheet (Adapted from F3-M&E Form 5 of DepEd TEC) and End of Program Assessment of the Department of Education Regional Mass Training on the Enhanced K-12 Basic Education Curriculum was used as basis in determining the least mastered skills and concept of the teachers. The identified least mastered skills of the teachers were used as basis to develop a training design and materials to enhance the teachers' competencies on the Enhanced K-12 Basic Education Curriculum. These were: (1) solving problems involving sets; (2) using Venn Diagrams to represent sets, subsets, and set operations; (3) using a compass and straightedge to construct line segments and angles and construct perpendiculars and parallels; (4) analyzing, interpreting accurately, and drawing conclusions from graphic and tabular presentations of statistical data; (5) finding inductively using models and algebraically the product of two binomials, product of a sum and difference of two terms, and square of a binomial; (6) solving problems involving measurements such as perimeter, area, weight, time, speed, temperature, volume/capacity, and utilities usage (meter reading); (7) describing and illustrating well-defined sets, subsets, universal set, and null set; (8) solving problems involving real numbers; (9) defining and describing the union and intersection of sets and complement of a set; (10) collecting or gathering statistical data and organizing the data in a frequency table according to some systematic considerations; (11) illustrating, naming, identifying, and classifying triangles according to their sides and angles and derived relationships among the sides and angles of a triangle using measurement and inductive reasoning; and (12) explaining the basic concepts, uses, and importance of statistics. The result showed that prior to the conduct of the retraining; the competency of the teachers on the least mastered skills was average. Of the twelve competencies, only two competencies got an above average rating while the rest obtained an average rating, but after the conduct of the retraining the teachers acquired an excellent rating on all the competencies. It was also found out that there was a significant difference in the competency of the teachers before and after the conduct of the retraining. Hence, the developed training design and materials was effective in enhancing the teachers competencies on the new curriculum. [Draft]

[28P3Y-4] The Influence of Parents on Science Course Choice of Female Students (*A0512*)

Toshiko Amemiya*+, Katsuhisa Kagami, and Akiko Sato
Ochanomizu University, Japan

ABSTRACT There is a small proportion of women who choose scientific major and career in Japan. We hold a variety of science activities for girls from kindergarten pupils to university students as one of the mission to increase the number of female students who select science course. From the observation of the parents' behavior during the events and the questionnaires of each events, the influence of parents for the interest in science of students was discussed. For example, through the observation of cicada molting and experimental class about power generation, students and their parents share the interest of science, and it enhanced the interest in science for both the students and their parents. Although not all the parents did necessarily have the science background, they were able to participate without difficulty with the help of science course university students. In the manufacturing seminars, such as robot and mini four-wheel-drive toy car seminars, the attending fathers seemed to have more interest in manufacturing than mothers, they watched with great interest what their children were doing. In the symposiums which was carried out of the junior and senior high schools with female students as a target, scientific women who were active in various fields such as researchers and teachers were invited as speakers. The symposiums had two major effects. First, female students could have the specific image for scientific careers, and second, anxiety and resistance of parents (especially mothers) for their daughter going on to the science course were reduced. Because female students tend to be affected by the mothers' attitudes and opinions, the mothers' interest in science and the daughters' scientific experience from childhood are believed to lead to a career in science.

[28P3Y-5] Preservice Science Teachers' Learning of How to Teach NOS (*A0434*)

Sun Young Kim
Chosun University, Korea

ABSTRACT This study examined the preservice science teachers' NOS pedagogical knowledge construction through two consecutive semesters. During the first semester, the preservice teachers learned and reflected about what science is and how scientific knowledge has produced. As the instructional materials, the episodes of history of science were used. After the preservice science teachers learned about the nature of science, the preservice teachers planed and implemented the NOS lesson. They developed NOS teaching and learning activities, and had an opportunity of NOS teaching. Then the preservice science teachers wrote the reflective journals on their NOS teaching. The results showed that the preservice teachers constructed the NOS pedagogical knowledge. The preservice teachers significantly improved their understanding of nature of science and attitude toward NOS teaching ($p<.05$) after the first semester. Then the preservice teachers retained their understanding of nature of science as well as attitude toward NOS teaching. Even though the preservice teachers mentioned the difficulties of teaching NOS, about 90% of the preservice teachers mentioned the necessities of NOS teaching for the secondary students in school science.

[28P3Y-6] Study on Anatomy Teaching of the Ordinary Elementary School Science Learning Book in the Early Showa Era (*A0053*)

Tetsuya Suzuki
Tokyo Future University, Japan

ABSTRACT [Problem Statement] The root of this study is to explore the meaning of the breeding shed from the old elementary school in Japan. I have a hypothesis that specifically is related to the formation of the shed and the beginning of anatomy teaching at the elementary school and have been investigating those teaching plans at the time (Suzuki,2014; Suzuki,2015; Suzuki,2016 etc.). In this study, I pay attention to student's notes of science learning books at that time. [Purpose] It is clearly to the realities of anatomy teaching not listed on the government-designated science textbooks of elementary school in the early Showa era (1926-1935). [Methods] 1 The ordinary elementary school science textbooks and one of the ordinary elementary school science learning books are used in the early Showa era, attention to carps, frogs, chickens, rabbits and bivalve mollusks, to analyze the contents of anatomy teaching. 2 While the notes which are written on the ordinary elementary school science learning books are analyzed to clear the actual anatomy teaching, the parson who writes to them is investigated by the literature on him. [Results] Description of the anatomy was not shown in the then textbooks, while carp (description of the anatomy and anatomy charts), frogs (description of the anatomy and anatomy charts), chickens (description of the anatomy and illustration of visceral description of the anatomy), rabbits (description of the anatomy and anatomy charts), and bivalves (description of the anatomy and anatomy charts) were shown to animals that contains the contents of the anatomy shown in the science learning book.
A carp's part of student's notes was written as follows. 1 You need to use wax adding charcoal powder mixed evenly with beeswax and raw wax and then to move and harden on the plate. Its thickness is about 1 cm. You may have wax on the plate into the crack in winter. If you put it on a hibachi (which is a Japanese charcoal brazier) in a short time, it will return easily. 2 You need to beat the eyebrows above the eyes on the handle of the knife to kill the carp. 3 You should buy a carp of over 100 monme (1 monme ≈3. 75 g), and it is possible to burn and eat it which is shaken the salt after the dissection. [Conclusion] It became clear in the early Showa era that showed no anatomical content in the science textbooks, but was done teaching of anatomy and furthermore, were also dissected animals which were raised at the school.

[28P3Y-8] How Works the Super Science High School using Japanese Mathematics Textbook (*A0043*)

Minoru Itoh* and Tetsuya Kobayashi
Tokyo University of Science and Ryugasaki Daiichi High School, Japan

ABSTRACT Currently, some mathematics teachers concerns about student oriented lessons, which enhance students' autonomous and independent learning activities, rather than teacher-centered mathematics classroom lessons, especially gifted education (Hertzog, 2003). The

Japan Ministry of Education (MEXT, 2014) mentioned the importance of independent and cooperative learning which related to "active learning" and the necessity for establishing learning methods for active learning in mathematics education. We got the research funds from the MEXT since 2014 until 2018 for enhancing the gifted student mathematics and science literacy and promoting multilateral interaction among students. We changed this traditional classroom lesson to more student-centered for the gifted high school students. They are able to apply and use their knowledges of modern mathematics. Students also try to translate old Japanese language into modern Japanese and English during mathematics lessons. During this project, the gifted high school students create their original Sacred Mathematics (Rothman & Fukagawa, 2008). We prepared the student contest of their assignment where they introduced and presented in front of other students and teachers. These activities enhanced their self-confidence and self-esteem for their studying mathematics. They also had a chance to learn modern mathematics using English language from native English speakers during this projects. As a result of the questionnaires from the gifted high school students, we found that they improve their mathematical skills and language, using not only Japanese but also English. We applied and utilized group works and cooperative learning during mathematics classroom.

[28P3Y-9] Integrating Reading into Geometry Teaching (*A0377*)

Yi-Wen Su
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ABSTRACT Reading ability and lifelong learning are closely related. In recent years, countries are increasingly focusing on students' reading ability. In order to understand students' reading performance, a number of international assessments have been organized, such as PISA (Programme for International Student Assessment) and PIRLS (Progress in International Reading Literacy Study). In Taiwan, the Ministry of Education continues to promote reading education and develop practical teaching of reading programs to help students develop reading interests. They want to develop reading not just in mandarin education but also in various other disciplines, such as math reading, social reading, and science reading. In this study, a teacher educator and nine senior high school teachers collaborated to develop math-reading texts to help students improve their reading comprehension. The teachers used math-reading texts, conducted classroom instruction, and, according to the PISA guidelines, designed assessment questions and observed students' learning styles as a teaching reference. We developed reading materials, addressed geometric concepts—including the theorem of three perpendiculars—and created assessments for math reading, thereby enabling students to access and retrieve, interpret and integrate, and reflect on and evaluate information. A total of 81 female students of the eleventh grade participated in this study; they are all from the same girls high school in Taipei. They were divided into groups of three people. Further, each student was given a piece of A4 size paper and asked to fold it into an isosceles right triangle. The students individually read the practice text and then finished the worksheet in groups. After teaching, every student filled one questionnaire that was designed by the study group. These data were collected and analyzed by the teacher educator and in-service teachers. The results of this study indicated the following: 1. Retrieving and accessing process: We let student place set squares like the given diagram and observe that some students are unable to place set squares via reading guide. 2. Interpreting and integrating process: We let students read the illustration and proof of the following theorem: "If AB is perpendicular to a plane E and if from B, the foot of the perpendicular, a straight line BC is drawn perpendicular to any straight line L in the plane, then AC is also perpendicular to L."and let students explain the reason. We observe that most students can successfully explain the theorem of three perpendiculars. 3. Reflecting and evaluating process: Regarding the question" Place three set squares as shown, where in B, C, D, E on the desktop, please determine whether CB is perpendicular to BE.", most students can reflect over the operation and give a proof or disproof. Students should be provided with plastic set squares so that they can operate them conveniently. We find that this math reading activity can initiate students' exploration and we hope the results of this study can serve as a reference for senior high school mathematics teachers.

[28P3Y-10] Empower Elementary School Students to Learn Algebra through Remedial Teaching Materials and Learning Activities (*A0063*)

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ABSTRACT In view of "the equal opportunity for learning math", "the urgency about developing remedial teaching materials" and "the importance of learning algebra at an elementary level", this paper attempted to inquire into algebra remedial instruction for elementary school students. In this study, elementary algebra remedial teaching materials and learning activities were developed to suit various teaching situations. The lessons were designed in conformity with the grade one to six stages for algebra under the "Grade 1-9 Curriculum Guidelines" of Taiwan. The researcher set up a research group of elementary algebra remedial teaching, named "The Group of Design and Teaching Algebra", to develop teaching materials and learning activities. The participants of this group involved teachers at elementary schools, junior high schools and cram schools as well as undergraduates and MA graduates who care for Taiwan's math education development and math learning students. Thus far, twenty one sets of elementary algebra remedial teaching materials with different approaches have been developed, e.g. math games, math story books, authentic contexts and concrete operations. The purposes of these teaching materials and learning activities were to draw students' learning motivation and to help students learn algebra/solve word problems. Each activity also provided teaching guidelines, pretest, learning sheets, and protest for teachers. It could be helpful for teachers to understand students' learning situation deeply. Through these teaching materials and learning activities, the researcher tried to help students understand algebra could be useful and beautiful, and learning algebra can be fun. Hopefully, such systematical development of remedial teaching materials for algebra could help teachers with algebra remedial teaching in their

classrooms, and improve elementary school students' core competence in algebra in preparation for more advanced math in the future.

[28P3Y-11] Promoting Children's Thinking Skills through Board Games (*A0526*)

Yu-Chi Chao

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ABSTRACT Board games are becoming increasingly popular in Taiwan recent year. The trend has also dovetailed with teachers' increasing in-class use of board games. The purpose of this study was to promote children's "problem solving", "metacognition" and "attitude toward mathematics" through board games. A one-group pretest-posttest design was adopted in this research. The participants were 47 10-12 years old students in East Taiwan. Board game instruction included "Rummy", "Blokus" and "Da Vinci code" was provided during 18 weeks. The self-designed "Problem solving and Metacognition Scale" and "Attitude toward Mathematics Scale" were used in the study. The results indicated that board games instruction could enhance the students' thinking skills and attitude toward mathematics. Based on the research results, some recommendations were provided for board game instruction designed and further research.

[28P3Y-12] Opinions of Japanese University Students about Issues of Bioethics: Comparison between Male Students and Female Students (*A0005*)

Junko Iwama*[1], Kunio Umeno[2], and Shizuo Matsubara[1]

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ABSTRACT Bioethics relates to every aspect of life in nature and social environments. In recent years, the necessity of guidance about the "preciousness of life" has been proposed by many researchers for science education. However, our previous research has revealed that implementation rate of the issue of bioethics in Japanese school education, in lower secondary school was about 6%, and upper secondary school was about 34%. They had learned as subject at the upper secondary school, "Contemporary society and Ethics" was 14%, "Biology" and "Integrated studies" were 9%, "Health and physical education" and "No idea" were 1%. And the content they had learned, "Organ transplantation and brain death" was 20%, "Life and Birth", "DNA, iPS cell and Clone" and "Death with dignity and Terminal care" were 5% (Iwama and Matsumoto, 2012). In this study we investigated Japanese university students' opinions about issues of bioethics and compared between male students and female students. The methods are as follows: We investigated 584 students' opinions (275 males, 309 females) about "genetic diagnosis", "amniotic fluid examination", "organ transplantation and brain death" and "preimplantation genetic diagnosis" and their interests on bioethics by questionnaire, from July 2012 to September 2014. The questionnaire is based on Iwama et al. (2014). The results are as follows: Firstly, 75% (206 of 275) of male students and 72% (221 of 309) of female students were affirmative toward "genetic diagnosis". Secondly, 73% of male students and 65% of female students were affirmative toward "amniotic fluid examination". Thirdly, on "organ transplantation and brain death", 77% of male students and 80% of female students approved "conditional promotion", or "promotion". So the majority of the students were affirmative toward "genetic diagnosis", "amniotic fluid examination" and "organ transplantation". Finally, on "preimplantation genetic diagnosis" which is to treat the first child who is suffering from "Fanconi anemia", 34% of male students and 37% of female students approved "conditional restriction", that is, "We should not expect the second young child to become the means of the treatment". And 39% of male students and 33% of female students approved "restriction" or "negation". So, 73% of male students and 70% of female students had negative opinions. On students' interests about the issues of bioethics, 68% of female students had interests about it but male students are 35%. There is also a significant difference between "male students" and "female students" on "genetic diagnosis", "amniotic fluid examination" and "organ transplantation and brain death", according to a statistical test. Bioethics relates closely to the body and life of living things, so we would propose that issues of bioethics should be taught in lower and upper secondary school science.

[28P3Y-13] Exploring the Relationships between Taiwanese High School Students' Scientific Epistemic Views and Decision-making Style under the Context of Environmental Education (*A0133*)

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ABSTRACT In recent year, people's environmental awareness has increased. When encountering the environmental issue, how students think about scientific knowledge and make the decisions might influence how they respond to it. The purpose of this study was to investigate the relationship between students' scientific epistemic views and their decision-making style under the context of environmental education. In this study, the participants were 231 Taiwanese students, aging from 15-17 years old. There are 76 male students and 155 female students. All of the participants completed two questionnaires. The scientific epistemic views (SEV) was used to investigate students' view of scientific knowledge, and the general decision-making style (GDMS) questionnaires, which modified from Scott and Bruce (1995), was performed to reveal students' habitual response patterns when people confronted with a decision situation. The SEV questionnaire included five factors: "invented and creative nature of science," "theory-laden exploration," "changing and tentative feature of science knowledge," "role of social negotiation," and "cultural impacts." The original GDMS questionnaire survey consisted of five factors, that is, "Rational," "Intuitive," "Dependent," "Avoidant," and "Spontaneous." Through exploring factor analysis, a total of 12 items with three factors were kept in the final version of the SEV, including "invented and creative nature of science," "role of social negotiation," and "cultural impacts." The general decision-making style questionnaire kept 22 items with five factors in the final version of the GDMS. There are gender differences that male students have a higher score than female in "Spontaneous" decision-making style and "the role of social negotiation" in SEV. The stepwise regression analysis was used to

understand how students' SEV related to their decision-making styles. The result revealed that scientific epistemic view as "invented and creative nature of science" can make positive prediction to the decision-making style as "Rational," "Intuitive," and "Dependent." The "role of social negotiation" can make positive prediction to the as "Rational," "Intuitive," and "Avoidant." Moreover, students held mature views of "cultural impacts" tended to have decision-making styles as "Dependent" and "Spontaneous." Based on the results, practical implications for environmental education and suggestions for future research are discussed.

[28P3Y-14] Effects of School-Community Joint Science Programs about the Abandoned Pet Issues (*A0150*)

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ABSTRACT Recently, The Korean Ministry of Education initiates a new educational movement called "Free semester," which gives students more opportunities to find their own interests and dreams over a semester in for the 7 grade. For achieving the aims, we designed and implemented a School-Community Joint Science Programs (SCJSP) about abandoned pets. The SCJSP includes various activities such as investigating their local issues interviewing local professionals and residents to ask their opinions on the issues, and visiting and utilizing local resources (e.g. veterinary clinics, animal rescue centers, community service centers etc.). We assumed that this SCJSP would promote students' understanding of their communities and character and values as future citizens. One hundred ninety 7th graders from 4 schools participated in this program over 8 weeks. We collected data from diverse sources. First, we examined students' science knowledge on abandoned pet issues (multiple-choice type and 10 items consisted of Basic Knowledge, Social Outcomes and Precautionary & Countermeasures). Second, we also administered a questionnaire which measured students' character and values by Lee et al. (2013) (5 point Likert type scale and 20 items consist of Ecological worldview, Social & moral compassion and Socioscientific accountability). Third, we conducted interviews with the participating students to explore their experiences of this program. In results, there was statistically significant differences on the total average score of science knowledge ($t = -.3.447$, $p < .001$) between pre- and post-tests. The percentage of correct answers remarkably increased in basic knowledge, especially on the item on pregnancy periods of dog and cat (6.3% to 36.8%), animal commerce (50% to 69.5%), and animal registration system (53.2% to 72.6%). In addition, the total average score of character and values significantly increased after the program ($t = -4.058$, $p < .000$). There was statistically significant improvement on all the three sub-components; ecological worldview ($t = -3.517$, $p < .001$), social and moral compassion ($t = -3.505$, $p < .001$) and socioscientific accountability ($t = -3.298$, $p < .001$). Based on the results, we expect the SCJSP provides school teachers the information on new teaching-learning methods for science education by jointing the familiar informal settings. It also brings students to experiences on understanding their places where they live by participating in such community based program.

[28P3Y-15] Exploring Undergraduates' Conceptions of Environmental Education in Taiwan: A Phenomenographic Analysis (*A0072*)

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ABSTRACT Environmental education is an important issue of school education. Recently, educational researchers have used the phenomenographic method to investigate learners' various learning experiences, such as conceptions of learning, and identified that learners' conceptions have a potential impact on their learning progress and learning outcomes. In the field of environmental education, several studies had focused on learners' attitudes and knowledge regarding environmental education. However, learners' conceptions of environmental education have not been well investigated. This study aimed to explore the conceptions of environmental education among undergraduates in Taiwan. Research data were collected through individual interviews with 18 (10 males) undergraduates from freshman to senior in Taiwan. They were from 16 universities from the northern, central and southern parts of Taiwan. All of them were majoring in different departments (such as engineering, business, science, medicine, art, and marine science). And, they had taken environment related subjects in their courses, especially in science courses, from high school to college. The interview data were analyzed by using a phenomenographic method. As a result, this study initially identified six qualitatively different categories of conceptions, that is, learning environmental education as "fulfilling the requirement of test," "receiving information and knowledge about environment," "disseminating and communicating," "understanding the environment," "solving the environmental problems," and "reflect thinking." Moreover, many of the students held the conceptions of environmental education as "disseminating and communicating" and "understanding the environment." The implication of the findings to improve education programs and the course design of environmental education are also discussed.

[28P3Y-16] Consciousness on the Relationship between Science and Mathematics: Focusing on the "Unit" (*A0444*)

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ABSTRACT The relationship between science and mathematics is closer than that of other subjects. There are several studies about the relationship between science and mathematics. For example, studies have examined how these two subjects should be located in the content curriculum (Lonning&DeFranco, 1997; Huntley, 1998), others have considered the topic from the viewpoint of context dependency （Ishii et al.,1996; Obara＆Andoh, 2011), and so on. In science lessons, it is frequently seen that students think in a mathematical way when they arrange and analyze natural things and phenomena as well as when they attempt to grasp relationships between variables. On the other hand, in mathematics lessons, it is often seen that they solve some problems using inductive and deductive ways of thinking and use figures, tables and graphs. Though the association between those two subjects is close, each subject is learned independently in the

scholastic curriculum in Japan and cross-sectional studies have not been carried out. Here, we focus on "a unit" which a section of content which includes science and mathematics. We investigated in Japan and another country about consciousness on the relationship between science and mathematics with "unit" as a keyword. In this investigation the same questions were used in two countries to examine the differences in consciousness in mathematics lessons. An investigation in Zambia was performed with 11th grade students (N=113) and compared with the same grade of high school students (N=108) already investigated in Japan. Some examples of the questionnaire are: "We need to use this unit in our daily life," "This unit is useful in enabling me to write a numerical expression from a problem," and so on. The results of the questionnaire were checked by the Wilcoxon rank sum test and showed that gender difference was seen in only seven items in Japan, but was seen in many items in Zambia. To determine whether the inclination of the responses of the survey was affirmative or negative, Fisher's exact test was used. A significant difference was seen in many items. The two schools have a different learning history, and this survey suggested there is a difference in the way students think about a "unit."

[28P3Y-17] Exploring the Influence of Prior Knowledge on Evaluating Scientific Explanation through Eye-Tracking (*A0262*)

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ABSTRACT Ability to evaluate scientific explanation is an important competency of scientific literacy. Prior knowledge is a crucial cognitive resource and will affect attention allocation. Experts and novices may pay attention to different zones of information and yield different task performance. This study uses eye-tracking technology to investigate students' cognitive process by analyzing their attention allocation and information integration during scientific explanation evaluation. Two research questions were addressed: during tasks of scientific explanation evaluation, (1) how do students with different prior knowledge pay attention to key zones of information (including context , question , data table , and given scientific explanations) in terms of first-pass (FPD), look-back (LBD), and total fixation duration (TFD), as well as total fixation count (TFC)? (2) How do they integrate information between these key zones of information in terms of inter-scanning counts (ISC)? 32 undergraduates were grouped into high- (HPK) and low-prior knowledge (LPK) groups according to their score on a biology concept test. The students underwent a task of science explanation evaluation on enzyme. They read the context and a research question of a simulated scientific inquiry, analyzed a set of second-hand data, and made judgments on quality of claim, evidence, and reasoning for two given scientific explanations. Each zone of information (so called as interested area, IA) was presented one at a time, and their eye-movement were recorded during the task and analyzed in terms of four indexes: FPD, TFD, LBD, and TFC for the six IAs as well as the ISC between from claim, evidence, and reasoning to other IAs. Participants also reported their thinking process in a retrospective interview. Score of the biology concept test was 4.31 and 3.53 for the HPK (n=17) and LPK group (n=15), respectively. Our findings indicated that regarding FPD no differences were observed between the two groups on other IAs. Regarding TFD, both HPK and LPK students spend relative more time on reading the given explanations than the other IAs. For between-group comparison, the HPK students exhibited more TFD and TFCs on examining the two given scientific explanations than their counter cohort. The HPK group also showed more regressions (LBD) to the context, inquiry question and scientific explanations than the LPK group when judging quality of explanations. In contrast, the LPK group spent longer time on examining data tables. Regarding ISC from the given explanation to other zones, the HPK group showed more cross-references from evidence to context and from claim to data table, whereas the LPK students demonstrated more ISC from evidence or reasoning to data table. The above findings suggest that the HPK students underwent deeper cognitive processes when reading the given explanations and spent more efforts on examining the coherence between the given explanations, especially reasoning, and the inquiry questions. The LPK group relayed on using information from the data table for explanation evaluation. The quantitative data was also supported by the interview data. Due to the space limit, the qualitative data, discussions and implications will be reported in the full paper.

[28P3Y-18] The Influences of Junior High School Students' Environmental Literacy on Water Pollution Curriculums (*A0050*)

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ABSTRACT This study aims to explore the influences of junior high school students' environmental literacy on water pollution curriculums in Taiwan. In this study, the definition of environmental literacy indicates environmental cognition, attitude and behavioral intention. In this study, teachers developed a new localization curriculum about water pollution to improve junior high school students' environmental literacy. The localization curriculum is related to their daily life such as the detection of water quality of the river which nearby their school. There were ninety junior high school students participated in this study. All participants needed to complete the environmental literacy questionnaires both before and after learning the localization curriculums about water pollution. In this study, the results show that the students' performances of environmental literacy are significantly better after learning by the localization curriculums than before. The localization curriculums about water pollution will be introduced and further implications and suggestions will be discussed in this study.

[28P3Y-19] The Analysis of the Characteristics of Argumentation in the Scientific Inquiry Discussion Process of Elementary School Students (*A0432*)

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ABSTRACT The fundamental purpose of the science classes is to train the citizens with scientific literacy, where they can address the surrounding problems with a critical and rational thinking. The process of scientific inquiry is not a simple experimental activity, but a process of addressing the problems through scientific communication, in which the argumentation activity is a type of scientific communication. However, scientific inquiry discussions accompanying the scientific argumentation activities are rarely performed in the actual classes, due to the lack of students' capabilities to manage the experiment, and the insufficient readiness of students to participate in the discussion. In this study, we developed and applied a problem-solving task for the elementary students to organize the scientific argumentation activities, and analyzed the characteristics of argumentation activities during the rebuttal phase of the scientific inquiry discussion process, mainly with the epistemic enactments and Collaborative construction. The objects of this study consisted of 18 elementary school students in six teams who have participated in and made it into the 2015 SESE Nara Scientific Inquiry Discussion Competition finals. The data collected were the recorded videos regarding the discussion contents, the inquiry report, and interview materials. Among the materials, the recorded videos were used as a foundation to make an analysis of the characteristics of argumentation expressed in the rebuttal phase. Using the DREEC (Discourse Register on the Evidence-Evaluation Continuum) discussion analyzing framework, mainly the characteristics of epistemic enactments and collaborative construction were compared and analyzed. The teaching principle to improve the argumentation activities was also sought. As a result, we could comprehend the process of developing a epistemic standard of the argumentation, and the process of collaborative construction of argumentation activities, which are applicable to each phase of data-evidence-pattern-explanation. We could establish a detailed teaching strategy to improve the argumentation activities in the rebuttal phase, based on such findings. Using the results, we look forward to finding ways to improve the teaching method in the rebuttal phase of the scientific inquiry discussion, and seek ways to facilitate the inquiry-, experiment-, and discussion- focused science courses. Also, we will discuss the means to implement an effective scientific argumentation program.

[28P3Y-20] Development of Metacognition Questionnaire in Thai Contexts (*A0533*)

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ABSTRACT Globalization, economic necessity and aging society demands new generations of science and engineering workforces. Today students have to be taught and trained the 21st century learning skills, so they are career-ready and equipped with critical thinking, problem solving and communication skills. Metacognition plays important roles in development of higher order thinking skills, including problem solving and critical thinking skills. Metacognition refers to "thinking about thinking" or our ability to know what we know and what we don't know. This study aimed to develop Metacognition Questionnaire (MQ) by using mixed methods. Firstly, the authors reviewed 120 literatures on topics of metacognition and found that Schraw's framework is the most frequently cited in the literatures. Three experts in education and eight undergraduates in science-related majors were interviewed with a protocol based on Schraw's framework. These responses and items from Metacognitive Awareness Inventory developed by Schraw, G. and Dennison, R. S. (1994) were combined and used in developing an item pool for our questionnaire in Thai language. The item pool consisted of 92 items and was evaluated and then reduced to 54 items, classified into 8 groups of Metacognition aspects of (1) Declarative knowledge, (2) Procedural knowledge, (3) Conditional knowledge, (4) Planning, (5) Information Management strategy, (6) Comprehension monitoring strategy, (7) Debugging strategy, and (9) Evaluation. A preliminary version of MQ was piloted with 50 undergraduates from faculty of science, agriculture, engineering, and agro-industry. Descriptive statistics, reliability analysis and factor analysis were performed. The collected measurements of total score did not indicate any significant outlier, or the extreme observations. The 2 sample t-test analysis showed that there is no statistically significant different between the total score measurements of male and female subjects under 95% confidence, with no restriction on equal variance. The analysis of reliability using Cronbach's Alpha measure indicated that the set of items are all agreed and correlated with in each group. The values of the Cronbach's Alpha measure ranges from 0.715 to 0.849. This asserted that the items developed in each category are reliable measurement for the construct variable of interested. In summary the factor analysis also helps confirm that all the items are sufficient to obtain the construct traits. Hence all the 54 items developed are reliable and sufficient to be used for large data collection.

[28P3Y-21] Devising a National Index for Natural Hazard Awareness (*A0390*)

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ABSTRACT Natural Hazards (NH) and Natural Disasters (ND) have been increasing in frequency and magnitude since the 1950s creating a need for citizens to increase their level of awareness of NHs/NDs. Increasing awareness of NHs/NDs among citizens can increase the chances that society will take steps to reduce the risks of NHs/NDs. At present, no awareness index exists to measure the average awareness of NHs/NDs among national citizens. A framework is put forward outlining five components of NH/ND awareness including the physical risks and human responses. These components include: (1) risks for NHs; (2) population exposure to NHs; (3) planning in risk reduction; (4) emphasis in education; (5) media influences. In this study, an awareness index is calculated for six countries: United States, Indonesia, Japan, Philippines, Papua New Guinea and Estonia. Results indicate that NH/ND awareness among national citizens varies widely among the world's nations'.

[28P3Y-22] The Study of Scientific Thinking Literacy Departments: Comparison of Science Education-related Departments and Non- science education-related Departments (*A0282*)

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ABSTRACT The goals of this research are to develop the Computerized Scientific Thinking Literacy Test for Undergraduate (CSTLTU) and to evaluate the differences in scientific thinking literacy between the science education-related departments (SERD) and the non-science education-related departments (Non-SERD). The items of CSTLTU were designed as contextualized testlets, which are similar to the Programme for International Student Assessment (PISA). Two aspects of assessment, the cognitive ability (Concepts of Science, Objective Judgment, Causality Judgment and Critical Reflection) and affective attitude (Objectivity, Exploring Causality, Critical Thinking and Scientific Attitude) are included in the test. Test contents were designed according to the dimensions above. Participants were 4,723 undergraduates from 31 different departments including 1,544 SERD students and 3,179 Non-SERD. Each student answered two or three testlets, containing 7-8 items of cognitive ability and 7-8 items of affective attitude. Unidimensional item response theory was utilized to estimate students' latent traits. The results show that CSTLTU provides good reliability and discriminant validity in both cognitive ability and affective attitude. Besides, SERD students significantly perform better than those from Non-SERD in both cognitive ability and affective attitude. The effect size in cognitive ability was .17 and affective attitude was .16. Overall, SERD students had better performances in scientific thinking literacy.

[28P3Y-23] Transition of Astronomy Curriculum in Japanese Schools and Spatial Cognitive Ability of Elementary and Junior High School Students (*A0284*)

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ABSTRACT In 1998 Japanese astronomy classes were shifted from grade 7 to grade 9, as advanced spatial cognition is required to understand astronomy. Consequently, students don't learn astronomy from grade 5 to grade 8 because of this change. Agata (2004) reported the elementary school students had low recognition of astronomical events, such as 42% of students support the Ptolemaic theory and 53% of students do not understand the reason for waxing and waning of the moon. However, detailed data was insufficient to consider this impact on the spatial cognition of students. The major purpose of this study are as follows. (1) To provide a comparison of the spatial cognition of elementary and junior high school students in 1985 and 2007 (2) To study the impact based on the difference of the astronomy curriculum. In this study, we investigate the spatial cognition of about 2000 students from grade 4 to grade 9, specifically, the relationship between the age when astronomy was learned and the understanding of the hemispherical concept, the left-right concept and the spherical concept. We conducted a paper test asking what some spheres would look like in a dark room with a single bright light source in order to investigate students' understanding of the relation between the position of the moon and the phase of the moon. The major results of this study are as follows. (1) Hemispherical concept in 2007 is generally less well understood than in 1985 between grade 5 and grade 8. (2) Understanding of spherical concept does not go down, compared to understanding of left-right concept after students learn it. (3) Spatial cognition has improved between grade 5 and grade 8 although they do not learn astronomy, so the other effects can be considered. (4) At grade 9, understanding of each concept of spatial cognition in 2007 is almost the same or better than that in 1985. Although Agata (2004) stated that science education collapsed with the revision of 1998, in this study, we consider that the shift of astronomy classes from grade 7 to grade 9 led to a general improvement of spatial cognitive ability. In addition, we have predicted better results in the revision of the 2008 added in 6 grade, to observe the moon and the sun, check the relation between the position and phases of moon. So, we will investigate the spatial cognition ability of students under the current curriculum guidelines of the revision in 2008.

[28P3Y-24] The Evolution of the Curriculum in Chinese Preschool Science Education (*A0414*)

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ABSTRACT This paper studies the development of the curriculum in Chinese preschool science education from back in history to the modern times and to the years after the founding of People's Republic of China. The curriculum in Chinese modern preschool science education can be further divided into five periods, that is following the teaching style of the former Soviet Union, using "common sense" to teaching, designing "scientific curriculum", engaging students to explore "scientific fields" and encouraging them to learn through practice. Based on the analysis of Chinese preschool science curriculum during different periods, the paper shows the evolution of the curriculum in Chinese preschool science education. The conclusion can provide thinking and enlightenment to the reform of Chinese preschool science education. [Draft]

[28P3Y-25] Study on Double-guard Web-based Interactive Teaching Method in Introductory Physics Class (*A0623*)

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ABSTRACT An Internet-based teaching method is introduced and assessed quantitatively in this paper. This teaching method enables the teachers to test the freshmen in university before and after each lesson by the internet, and merges the quantitative teaching research and assessment into daily teaching activities. Using this method, the teachers can organize classroom teaching according to the feedback of the pre-test before a lesson and arrange the content of discussion classroom according to the post-test results after the lesson. So teachers can understand the initial knowledge states of their students well before a lesson and focus their teaching on the misconcept and status of their students, and make the teaching effectiveness of the teaching classroom increase. In order to make sure the effectiveness of this teaching method, the pre/post-tests

of BEMA (Brief Electricity and Magnetism) test papers respectively conducted on the experimental and control classes. The teaching method was used in the experimental class and the traditional teaching was conducted in the control class, both methods were lasted in three months. The result shows that the course normalized gain of the experimental class is 37.9% after deducting the ceiling effect, one time higher than the control class. These data indicate that this method obviously impacts to promote the course teaching effectiveness. The analysis on the reason why this method is effective is made in this paper. There is a significant difference between a classroom and course teaching effectiveness, and it is accepted by many education researchers. In this paper, their difference is first conformed by the teaching experimental data, and introduced a course normalized gain and a classroom normalized gain for quantitative description. Taking the data of this paper for an example, it is roughly estimated that the influence of teaching steps outside the classroom teaching on the course teaching effectiveness is considerably large and a role of the self-learning ability is important in their learning process.

[28P3Y-26] Students Performance in Different Format of Evaluations: Digital vs. Paper-pencil Tests (*A0408*)

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ABSTRACT Paper-pencil tests have been widely used in traditional classroom, however, nowadays, more and more test are using digital equipments. This study is to explore if consistency exists when students among those who perform well in digital assessment app and those who perform well in paper-pencil testing. Subjects of this study are 176 students of seven 6th grade classes at an elementary school. To compare students' performance in different formats of tests, before the tests, all students were provided with reading materials about microalgae and study these materials. After that, all students took digital assessment and paper-pencil tests related to microalgae. Their performances in these two different formats of tests are compared. The digital assessment was implemented by a self-developed APP. Students' achievements were judged by their performance during small group competition. For the purpose of understanding if there was any consistency among those with outstanding performance in digital evaluation and in traditional paper-pencil test, this study had chosen those performed well in digital assessment to enter semi-final as outstanding performance group and those who were not chosen to enter semi-final as contrast performance group. This study organized paper-pencil testing scores of all students in ranking, assigned the top and bottom 27% percentile as high and low score group respectively, the rest was assigned as mid-level score group. Comparison was made to determine whether students with outstanding performance in digital assessment would achieve any level of consistency in paper-pencil test. Independent sample t test was conducted to compare means of outstanding performance group and contrast performance group. Study results indicated 65% of all students of digital assessment outstanding performance group, entered high scoring group in paper-pencil test, and these students also achieved significantly better score than students from contrast performance group in paper-pencil test. This meant students with better score in digital assessment competition also achieved higher score in paper-pencil test. Nevertheless, a small percentage of students from mid-level and low scoring group in paper-pencil test also entered outstanding performance group in digital assessment. Similar results were also been identified in past studies. In many cases, students with low academic scores could achieve top 3 ranking in digital assessment competition. According to interviews, students stated that questions in digital assessment competition were presented differently from traditional paper-pencil test, they were more likely to raise interest in reading and thinking. It seems easier to apply concepts learned from studying materials in digital assessment competition. Therefore, digital assessment, such as the APP used in this study, may allow students with high scores in competition achieve same scoring outcome in paper-pencil test but also raise learning interest of students with mid-level and low scores and help them enter high scoring group in digital assessment competition.

[28P3Y-27] A Learning System to Enhance Imagination and Creativity Learning for University Engineering Students (*A0036*)

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ABSTRACT The Engineering Education in university usually focused on computing and reciting formula without training the imagination and creativity. This study builds a learning system to enhance imagination and creativity learning for engineering students in university. The courses of this study were designed for green energy learning, such as wind power, solar power, biomass energy and etc., and develop the concept of environmental protection. In order to cultivate many engineer experts with imagination and creativity of engineering, the learning materials were developed by POE (prediction-observation-explanation) model, and designed learning strategy by flipped instruction model and MOOCs (Massive Open Online Courses). A quasi-experiment will be conducted in a university engineering course to research the following question: Do the students who learn with the learning system have better learning performance on imagination and creativity? The prediction-observation-explanation (POE) model is an approach to promoting students' conceptual changes by actively confronting the students' prior knowledge and encouraging knowledge application. As well as construction, which embraces the tenets of constructivism, and is proposed by White and Gunstone (1992). In the solving engineering problem process, student must follow up three steps: (1) analyze the problem, and find all technical points to this problem; (2) Select and integrate proper techniques to compose the solution to this problem, then make sure the solution is feasible by simulation and experiment to complete the solution; (3) explain why the solution is feasible to this problem. While students are doing analysis and using POE model to solve problems, student's imagination and creativity could be improved. Besides, the defects of traditional classroom learning model were improved by flipped instruction model and MOOCs. Student must learn with the MOOCs by themselves and solve the engineering problem, and finish

homework. Student's learning and solving engineering problem behaviors would be recorded with the three steps creation process. We will analysis students' behavior data and explore the factor affecting the imagination and creativity. To evaluate the effectiveness of the imagination and creativity learning process, a quasi-experiment will been conducted in an university green energy project course to examine the students' learning performance and record the learning and solving engineering problem behaviors. The expected result is that student's learning performance, imagination and creativity will be improved and the factor affecting the imagination and creativity will be found.

[28P3Y-28] Extracurricular Activities with Practical Experience Based on Expanding 'Seeing' (*A0410*)

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ABSTRACT [Problem Statement] In science education, it is important for learners to acquire the ability to think scientifically, in addition to the knowledge of science. Learning through practical experience is one of the most effective methods of acquiring the ability to think scientifically. [Purpose] We aim to construct a system of science education involving a series of practical activities. The subject matter is 'seeing', including not only by visible light but also by infrared, ultraviolet, and electron (for example, using an electron microscope). Sight is one of the senses, so the subject matter is approachable, and learners can really experience the development of science and technology by studying instruments for seeing. We tested our science education system twice in a junior high school extracurricular setting, with equipment that we devised and made. We will report the contents of these extracurricular activities in this presentation. [Methods] First, we introduced the mechanism of seeing, the construction of the human eye, refraction by lenses, the history of the development of telescopes and microscopes, and kinds and structures of electron microscopes. During this introduction, we showed students pictures and figures on a projector. These pictures were extracted from junior high school textbooks, so the students could clearly see the relation between the contents of the extracurricular activities and the subjects they had learned in their classes. Next, students were separated into three groups (8–10 students per group), and each group engaged in three activities on a 20-minute rotation: learning by demonstration, making a simple microscope, and observing a hair with an electron microscope. [Findings] From students' reactions, we gathered that the practical experiences were effective. Lessons that involve practical experience make a strong impression, so students are more likely to retain new knowledge and become intrigued by the subjects. Because each student had to work with precision in the process of making a simple microscope, students felt a sense of achievement when they were able to observe an onion's epidermal cell. Experiences like this are indispensable for spontaneous learning. Learning cross-sectional units of the textbooks by focusing on 'seeing' was a fresh approach for students, allowing them to find a new point of view. Surveying the history of development concerning 'seeing' led students to think about the future development of science. [Conclusions] This system of science education through practical experiences is effective for teaching science, as this experience teaching junior high school students the science of seeing shows. It could also be fruitful in other settings, especially for teaching physics to medical students, teaching science literacy to humanities students, and for outreach.

[28P3Y-29] Developing Students' Scientific Literacy in Chemical Equilibrium Teaching (*A0494*)

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ABSTRACT How to develop students' science literacy is a research focus in science education field. The teaching strategies are constructed based on the insight of scientific literacy in program for International Student Assessment (PISA).The teaching strategies contain the following: Analyze scientific knowledge advanced to clarify knowledge clues; Analyze PISA background to determine the teaching carrier; Analyze PISA knowledge type to determine the teaching train of thought; Analyze PISA cognitive requirement to design the core questions; Analyze PISA scientific capacity to design the teaching activities; Analyze PISA scientific literacy contained to implement teaching design well. Chemical equilibrium is the core teaching concept in high school chemistry teaching. Select "dissolution equilibrium of insoluble electrolyte" teaching content to implement these teaching strategies. First of all, analyze scientific knowledge advanced to clarify the five knowledge clues. Secondly, Analyze PISA background to determine that the teaching carrier is silver chloride precipitation. The teacher and students can centrifuge silver chloride precipitation and divide into upper clear solution and precipitation, and then put the precipitation into water to check if it can dissolve or not. And then, analyze PISA knowledge type and PISA cognitive requirement to design the six core questions including the following: "Can silver ions and chloride ions produce precipitation entirely? How to check that?", "Where do silver ions in the precipitation solution come from?", "How to design experiments to check the hypothesis that silver chloride precipitation can dissolve?", "Review the process of the experiments to summarize the characteristics of insoluble electrolyte's dissolution.", "According to the particles in silver sulfide precipitation and silver iodide precipitation, write down the dissolution equilibrium of insoluble electrolyte.", "How to write the chemical equilibrium constant of silver chloride dissolution equilibrium?". Then, analyze PISA scientific capacity to determine the teaching activities of this lesson is to check if silver chloride precipitation can dissolve or not, and explain the reason as the science inquiry activity. In the end, implement the teaching design in order to develop students' science literacy levels. The research selected a high school in fangshan district of Beijing in China to implement the teaching practice research, there are both forty students in the experimental classes and the comparative classes. By the results of students' performance in pre- and post-tests designed, there is a significant difference of the participators' performance between pretest and posttest, and students' scores in post-test rises obviously. Those illustrate that the teaching strategies based on the insight of scientific literacy in PISA

can effectively develop students' scientific literacy.

[28P3Y-30] Enhancing Gifted Students' Scientific Inquiry Skills through the Enrichment Triad Model (*A0445*)

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ABSTRACT The Enrichment Triad Model (Renzulli, 1977) consists of three stages: Type I Enrichment experiences are about discovering, stimulating and inspiring interest, Type II includes materials and methods designed to promote the development of thinking processes, and Type III products can be completed by individual or small groups of students and are always based on students' interests. This study is based on ETM, designed 10 weeks gifted science curriculum with five stages included "defining the problem", "design and plan", "test and experiment" , "analyze data" and "communicating the finding". Nine primary gifted students participated in this one-group pretest-posttest design study. Students chose their interested independent study topic after guiding teaching activities. "Scientific inquiry performance assessment", "scientific inquiry self-evaluation test" and "gifted science and mathematic study test" were used to assess students' respective ability and skills. The results revealed that gifted students developed better scientific inquiry abilities. There were significant difference in "design and plan" and "test and experiment" domin. Based on the findings of the present study, some recommendations were provided for science teaching and further research.

SPECIAL POSTER PRESENTATIONS

Special Poster 1Y (26th, 11:30-12:50)

[26SP1Y-1] A Study of Cooperative Learning in Secondary Mathematics Education: Focus on Enhancing of Communication Skills (*A0436*)

Hiroshi Katayama* and Minoru Itoh
Tokyo University of Science, Japan

ABSTRACT In this research, I will develop the teaching method of mathematics. According to the statement of the Ministry of Education (MEXT) in Japan, students' mathematical thinking is very important for their communication skills. The Central Council for Education in MEXT point out "cooperative learning" is necessary for improving communication skills. However, according to data (Ishikawa (2010)), cooperative learning is applied only 1% of junior high school classroom in Japan. And, Kubo (2013) also pointed out following; - One-third of the junior high school teacher in Japan is not so much emphasis on communication in class. - Many communications in the classroom is the response of students by the question of teachers. - Many math teachers in middle school have the ideal of class image of the problem-solving with the students, however, teachers say that in terms of mainly leadership cannot such a class. For solving these problems, I will develop and introduce the teaching method of mathematics with "cooperative learning". To achieve this goal, it erected five plans; 1. Basis research of cooperative learning 2. Investigation and selection of the cooperative learning techniques 3. Research and analysis of previous studies of cooperative learning 4. Determination of subject 5. Study and practice of the teaching method using cooperative learning I advanced 1-4. [Selection techniques] E.F.Barkley classifies cooperative learning in five ways; techniques of discussion, teaching each other, problem-solving, illustration, and writing. In this, I chose the technique of teaching each other. McKeachie et al. say that effective teaching method is teaching each other by other students. Among the five, this technique is easy to take the most communication. So, in this research, I will consider the teaching method using the technique of teaching each other. [Determination of the subject] I chose as a subject the proof of the Pythagorean theorem. 1st year junior high school education is to focus on to explain in theirs way. 2nd year's is to focus on to refine them, to clarify the basis, and to explain each other. And, 2nd year junior high school students learn methods of proof. To learn methods of proof is very important to improve communication skills. I chose the proof of the Pythagorean theorem, including all the contents of the figure of the junior high school.

[26SP1Y-2] Analysis of Teaching Method in Mathematics Education for Academic Development: Focusing on Proficiency Level (*A0575*)

Yoshiki Habe* and Minoru Itoh
Tokyo University of Science, Japan

ABSTRACT Small group learning is currently introduced in various schools around Japan in the aim of academic improvement of the student, while constantly improving the teaching programme itself. The Ministry of Education in Japan coined the term 「学びのすすめ」(JP: "Manabi no Susume", EN: " Recommendation for learning") and this has prompted numbers of academic researches around Japan to identify what promotes students' academic improvement. However, most of the previous researches that have been conducted, had a limited scope of only identifying the difference when large groups were split into smaller groups at the beginning of a semester, while disregarding their unit. Thus, this paper will suggest that further study should be pursued in identifying which small group learning situation turns out to be more effective. [Methods and Purpose] To investigate the teaching method which could improve academic development in mathematical education, this study focuses on both small group learning and proficiency-based learning. As sub-goals this study: - researches the historical background of small group learning and proficiency-based learning to identify the meaning of these two different learning methods; - analyses relevant articles and academic essays relating to a practical class introducing small group learning and proficiency-based learning; - considers the necessity of small group learning and proficiency-based learning; - specifically suggests in which unit small group learning and proficiency-based learning be introduced; and - researches the situation in the actual classrooms of these learnings. This study was conducted through following the methods mentioned above, and makes recommendations on how the small group learning and proficiency-based learning should be conducted.

[26SP1Y-3] The Development of Teaching Material about "Railroad" as Mathematics Activity (*A0465*)

Tomoaki Harada[1]*, Minoru Itoh[1], and Yuki Watanabe[2]

1. Graduate School of Mathematics and Science Education, Tokyo University of Science, and 2. Center for Innovative Teaching and Learning, Tokyo Institute of Technology, Japan

ABSTRACT This study is focused on developing the teaching materials to connect mathematics education and society related to railways. Program for International Student Assessment (2012) pointed out two reasons of its low performance than OECD member countries. First, students have less self-confidence in learning mathematics. Second, they feel that mathematics is not simply fun and no concern rather than other subjects. Therefore, it is necessary to let student be more interested in mathematics in their schoolrooms. So, we developed the teaching material using the railroad, which the students usually hold the train everyday life. We researched these four contents: (1) defining of their mathematical activity; (2) analyzing high school textbooks, reference books and college board examinations related to railroad material; (3) developing materials on mathematics related to railroads; and (4) clarifying effects that I take as division through the statistics of the questionnaires. We developed these four materials to link mathematics and railroad together. (1) Diagram (rail transit chart) and mathematics; students know when and where a train does cross relatively and pass by using diagrams and the math.(2) Gradient and mathematics; Japan is surrounded by the mountain and seas. Therefore a lot of gradients exist in the Japanese railroad. Students can work out how much the gradient is using knowledge of the trigonometric ratio.(3) The congestion rate in railroad, a service interval of the train and mathematics; students use mathematical formula to reduce the congestion rates adjusting interval of the string. (4) Path finding and mathematics; About the movement using the railroad, we clarify to use mathematics how you think about comfortable movement from the viewpoint of fare, time needed, and transfer number of times.

[26SP1Y-4] Engineering Tournament (ET): Promoting 21st Century Skills in Primary Science (*A0624*)

Xueqi Feng[1]*+, Yundong Qi[2], Yi Feng[2], Chengming Zhu[2], Xue Zhang Qimei Lin[2], and Yuan Xu[2]

1. The University of Hong Kong and 2. Nanjing Langya Road Primary School, Hong Kong

ABSTRACT With a growing demand to cultivate students having 21st century skills, especially the ability of creating knowledge, students are enforced to change their learning styles to adapt to the society. Applying "Engineering Tournament" (ET) instructional model in primary science education could promote students' 21st century skills. Specifically, research questions are: (1) How to design the ET to promote students' 21st century skills? (2) To what extent do ET promote students' creativity and innovation necessary for 21st century skills? (3) What are the beliefs and feelings of the students about the quality of their work on ET? ET belongs to a school curriculum, which is instructed by four teachers in different subjects. The content including topics of Mechanical Devices, Physical Structure, Electricity & Magnetism, and Force & Motion. A class of fifth graders in Nanjing participate in this study while they work on series of ET courses during one year. The ET teaching model includes six scaffolds: task allocation, brain storming, initial experience of competition, knowledge creation, evaluation and competition, communication and summarize. Electronic equipment records, questionnaires, interviews, data extracted from worksheets will be collected for data analysis. Findings will show that ET can develop students' creativity and innovation, which is an innovative objective for students' development and education patterns. Moreover, it could also improve the teaching practice, which is an innovation for students' studying and practicing: (1) ET can promote students' 21st century skills (2) ET can change teachers' roles. Further research will focus on intervention of the ET experiment among classes and exploration of diverse assessment strategies.

Special Poster 2X (27th, 11:30-12:50)

[27SP2X-1] Why Can 'Amateur Scientists' Continue to Devote Themselves in Their Scientific Practices?: Searching for Effective Scaffoldings to Encourage Students to Continue Their 'Doing Science' Activities in Their Daily Life Settings After Finishing School (*A0471*)

Yuuri Kimura

Graduate School of Mathematics and Science Education, Tokyo University of Science, Japan

ABSTRACT In the conventional research on science education and science communication so far, a typical dichotomy between scientists (professionals) vs. citizens (non-professionals) has been prevailing. In this scheme, scientists alone are regarded as the practitioner of science. However, there exists a different type of science practitioners within the citizens (non-professionals). Among them are so-called 'amateur' scientists (Stebbins, 1982). They are non-professional, but devote themselves to certain areas (for example, entomology or astronomy) of scientific activities, meaning that they serve as 'scientist.' Among Hodson's (1998) 'three major elements of science education' (learning science, learning about science, and doing science), the importance of 'doing science' in school settings has been emphasized especially in the Japanese context, but once they finished their schooling, from various socio-cultural reasons, most of them are, consciously or unconsciously, urged to escape from enjoying this 'doing science' activities in their daily life. However, the amateur scientists are rare case in terms of their continuous engagement in the scientific practice ('doing science') without expecting any rewards. If we can understand the reasons why they could continue to commit their own scientific practice, that is, socio-cultural contexts as well as their inner motivation, we might be able to deliberate possible and probable scaffolding to encourage students who love 'doing science' to continue their scientific practice after finishing formal schooling. Thus, in order to tackle the issue, firstly, investigated were to identify the motivations of amateur scientists and socio-cultural factors around them through a semi-structured interview (with Modified-Grounded Theory Approach, (Kinoshita, 2003), and successfully generated a hypothetical model of the reasons why they could continue to devote themselves into their own favorite scientific practices (Kimura, 2015). In this special poster presentation, the research plans of my next phase of the on-going project are presented for

receiving critical comments and suggestions.

[27SP2X-2] Synthesis of Ethenzamide from Methyl Salicylate as Teaching Material in High School Chemistry (*A0256*)

Ryo Saito* and Masayuki Inoue+

Graduate School of Mathematics and Science Education, Tokyo University of Science, Japan

ABSTRACT In textbooks of high school chemistry in Japan, Some organic compounds are introduced as components of pharmaceuticals. Since the students are familiar with such pharmaccuticals in their daily life, experiments dealing with such substances are expected to attract the students and thus to be highly effective in learning chemistry. In this study, as an advanced experiment for high school chemistry classes, we investigated the synthesis of ethenzamide which is one of the antipyretic analgesics from methyl salicylate, known as a popular anti-inflammatory agent. As the first step, methyl salicylate was reacted with aqueous solution of ammonia (NH_3 aq) in various conditions. The yields of salicylic amide were measured with 1H-NMR. When performing experiments in flasks or test tubes, bad smell of ammonia is a serious problem. So we used dilute NH_3 aq to quarter concentration of conc. NH_3 aq. Under this condition, the yield of salicylic amide reached to almost 50%, at 40℃ and 60 min. Using a vial container with a lid, we can use conc. NH_3 aq. In this case, the yield of salicylic amide also reached to almost 50%, at 40℃ and 60 min. Aiming to improve the yield, we are going to continue the investigation further.

[27SP2X-3] How Can We Encourage Students to Be Consistent in Their Explanations and to Improve Their Understanding? : Using the Particle Model to Explain Phase Change (*A0369*)

Yukiko Hirano* and Shuichi Yamashita

Chiba University, Japan

ABSTRACT This study examines how to help students use the particle model in explaining phase change. In Japan, almost all science textbook from elementary school to upper secondary school have some description of the concept of particle in each unit related to matter. Even though many teachers realize the importance of that concept, some assessment tests typically show that a large number of students have a poor understanding of it. In this study, the authors develop the classes about phase change. This unit is learned by first graders in lower secondary school: 12-13 years old students. The teaching materials and the class structures were developed referring to the review of previous researches. Kikuchi (2008) states the concept of particle consists of 2 levels. The first level is 'All matter is made up of too small particles to see.' and the second level is 'All matter consists of units of atoms or molecules or ions.' More recently, Kikuchi (2014) states that the first level of the concept can be divided into 6 facts. (1) There is nothing in the space between particles. (2) Particles do not disappear. (3) The mass of a particle is conserved. (4) The size of a particle is conserved. (5) Particles are perpetually in motion. (6) Particles pull against each other. Since second graders in lower secondary school learn atoms of molecules in Japan, the authors used the first level of the concept of particle and those 6 facts in the classes for first graders. Kakihara (2014) developed the teaching material which shows the model of gas phase by vibrating pellets, and the authors increased the size to be able to show the model of the phenomena to the students. In this way, the authors developed the materials to encourage students to explain in a consistent way by using particle model.

In the classes, the students conducted the experiments to change states of the following materials: water, ethanol and oil. Then the students explained the reasons for the changes in their densities scientifically in relation to changes in the conservation of matter using particle model. Before and after the classes the students tried pre-test and post-test, and the authors compared the results. The results indicated that students have come to be able to explain the reason for the phenomenon of phase change after the classes using particle model. They can also have explained the phenomena of the phase change of the matter which was not used in the class, but the classes still have room for improvement. The authors are set to develop the classes about temperature change attendant upon the phase change, and the students will also use particle model in these classes. This study will give us a chance to think about the effect of consistent explanation using the particle model for some phenomena to students' understanding.

Special Poster 2Y (27th, 11:30-12:50)

[27SP2Y-1] How Japanese Junior High School Math Teachers Prepare for Their Lesson Plan to Improve Student's Motivation? (*A0364*)

Shohei Omori[1]*, Minoru Ito[1], and Yuki Watanabe[2]

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ABSTRACT According to "Trends in International Mathematics and Science Study (TIMSS 2011)" and "Programme for International Student Assessment (PISA 2012)", the motivation for the mathematics class of the Japanese junior high student is lower than countries where have high scores of the performance test. Particularly, the ratio that students answered "I look forward to a class of the mathematics." and "I am interested in contents learning by a class of the mathematics." is less than international average. Therefore, we plan the improvement of the attitude that we are going to learn by improving "Attitude" in "5-Learning Outcomes" developed by Gagne and others (2005). In addition, we develop the guideline of the instructional design which improve the motivation using "Attention, Relevance, Confidence and Satisfaction model (ARCS-Model)" (Keller 1983) in the mathematics of the junior high school. Already, we researched about the actual situation of the motivation and the attitude of the Japanese mathematics, about the precedent study of the class design using the ARCS model in other subjects. Now, we research about the based on the class actual situation along the ARCS model for improving the motivation in mathematics classroom. We will build an instructional design to achieve the purpose that we wrote on the top in future based on the class actual situation along the ARCS model. We will develop the more precisely method of the instructional design. I intend to give a presentation on "How prepare for math lesson plan to improve student's motivation." mainly this time.

[27SP2Y-2] Development of Graph Theory Textbook for Educators (*A0140*)

Junpei Gohara*+, Mayu Ikeda, Iwao Mizukai, and Akifumi Sako
Tokyo University of Science, Japan

ABSTRACT This is an interim report of a project to survey textbooks of discrete mathematics for educators of mathematics. We focus on making a text of the graph theory for Japanese educators. Graph Theory is becoming more important not only educational communities but also in public in generally in recent decades, because societal demands on the information science is growing. However, this topic is hardly written in the textbooks of high school mathematics until now. It is desired for educators to learn about the graph theory. But learning Graph Theory in the same manner as mathematicians is difficult, because time and environmental constraints. Therefore, it is considered necessary to make educational materials of the graph theory that are specialized for educators. In this text of the graph theory we focused on a linear algebraic and a number-theoretical perspective. Methods in calculations in the graph theory is possible to be used for introductions of linear algebra, and their visual meanings are clear. As an example, the adjacency matrix is treated to give students motivations for learning the liner algebra. The adjacency matrix provides a visual meaning to a usual matrix, and it makes students understand matrices easier. It is possible that readers put some contents of this text directly into their curriculum of high school mathematics education. In addition, using the connections between graph theory and information science, geometry, and number theory, intuitive understanding of this topic is obtained easily through this text. The main part of this text is about the construction of the Ramanujan graph. Thinking about the "good graph" has led to construction of the Ramanujan graph. The Ramanujan graph is characterized by suppressed number of edges and effective connection of each points. These features are often useful, for example, in the case of making a graph of an efficient communication network. However, the specific configuration method of the Ramanujan graph had not been clarified until recently. For this reason, there are few texts that attempt easy explanations for the Ramanujan graph. This text gives a way to learn the graph theory to configure the Ramanujan graph in the shortest. This method easily introduces concepts of linear algebra, group theory, and number theory, and visuals of graph help to understand them. Readers of this text come to be able to teach the concept of linear algebra, group theory and number theory to students through visual ways.

[27SP2Y-3] Development and Practice of Teaching Materials of the Cycloid for Cooperation between Mathematics and Physics Subjects (*A0234*)

Daiki Inoue*+ and Hiromichi Itou
Graduate School of Mathematics and Science Education, Tokyo University of Science, Japan

ABSTRACT Educational Curriculums in Japan require a progressive educational program intended to make a mutual relationship among subjects. However, the upgrading and systematizing of study contents in each subject lead to weak connection among subjects. A typical example is the understanding of cycloid. A cycloid is the curve which yields the quickest descent and also has the property of isochronism. Proving isochronism remains a challenge. We propose to prove the isochronism by using high school mathematics and physics. It can be done through the aid of differential and integral calculus, parametric representation, fundamental mechanics, etc. The purpose of our study is as follows: 1) To develop teaching materials about cycloid curve and practice it in class; and 2) To make students realize the connection of mathematics and physics. The following procedures will be conducted: 1) Research how the cycloid is used in current school education; 2) Investigate the property of cycloid from both sides of mathematics and physics; 3) Develop teaching materials and educational programs; 4) Practice the materials for the second and third grade high school students; and 5) Analyze feedback from students about the practice. For future plans, we aim to develop teaching materials for integration with other subjects. Integration will not only be in Mathematics and Physics. We hope to get advices and suggestions about examples of overseas teaching materials which cove multiple subjects.

[27SP2Y-4] Practice of Experiment-based Active Learning Aiming at Connection with Modern Mathematics in Senior High School Mathematics (*A0179*)

Mayu Ikeda*+, Junpei Gohara, Iwao Mizukai, and Akifumi Sako
Tokyo University of Science, Japan

ABSTRACT We discuss advantages and demerits of an active learning model in an experiment-based group learning and develop a new active learning instructional material considering connection of modern mathematics. To support mathematical activities of students in classes, it is necessary to improve our teaching style from a conventional teaching in a lecture style to a student-centered active teaching. Here, active learning has been gained attention as one of student-centered learning activities. In Japan, "Active learning" has been used from the 2000s. Active learning was defined as "doing things and thinking about the things they are doing" (Bonwell & Eison 1991). From this passage, we emphasize "doing things" and "thinking about the things" in our practice. In this study, we introduce active learning for senior high school mathematics by "doing experiment" as "doing things". In practice of active learning, we use "Harmonic series (the leaning tower of coins)" and "Packing problems" as an instructional material in order to aim at student-centered mathematical activities. In "Harmonic series", we make students do an experiment. The students obliquely pile coins from an edge of desk and examine how far the coins we protrude from the edge of the desk in the experiment. There are four advantages of the instructional material: 1. independence of learning levels of students, 2. attracting interest of math-challenged students, 3. easy preparation and low cost, 4. connection with modern mathematics. For example, the concerning subjects of modern mathematics are the Riemann Zeta Function, the Basel problem, and so on. "Packing problems" has the above four advantages, too. It reduces an economic burden by diversion of coins prepared for the above "Harmonic series (the leaning tower of coin)" in two-dimensional packing problem classes. Although the conclusion of the Kepler conjecture for sphere packing is commonly seen in our daily life and easy to expect it, the conjecture was proved in only 2 years ago, 2014. Therefore, it is possible to deal with students interested in mathematics and students in a wide range of

scholastic ability. The process of the classes is as follows. First, we present one of the problems to all the students and make each student expect the result of the experiment. Next, students make some groups. Each group experiments and considers the result. Finally, they discuss the results in the class and come to a conclusion. We did a questionnaire survey to the students and observed the classes. The data was analyzed with a modified grounded theory approach. As a consequence, we observed that there are many diligent or self-paced mathematical activities of students and improvement of mathematical interest. Developing new instructional materials of active learning is achieved.

Special Poster 3X (28th, 11:30-12:50)

[28SP3X-1] Towards Edutainment Concept for Solar–related Knowledge: School Excursion Tourism and Landscape Adapted Orienteering (*A0213*)

Chan Wilco[1*+], Au Norman[1], Chow Cheris[2], and Sun Baifeng[3]

1. Hong Kong Polytechnic University, Hong Kong, 2. University of Macau, Macau, and 3. Wenzhou Washi Primary School, Hong Kong

ABSTRACT To accelerate the widespread application of solar technology in society, education of solar-related knowledge has been planned to diffuse to all walks of life and people of different ages. Nevertheless, the offerings on campus have always been limited to students in science discipline. To match the development, some institutions have designed courses to target students in general including those from non-science or non-engineering discipline. How to engage these students' attention and reinforcement their memory on the delivered knowledge are the key consideration in teaching plan. The project plans to deliver solar knowledge to college students (open to students of both Engineering and Non-engineering) first and organize a field excursion for them to teach (underprivileged) teenagers in junior secondary school. The solar-related knowledge being taught will mainly cover the new development of applied solar knowledge, the principle of solar energy driven water heater and PV panels for electricity. This may avoid duplicating the knowledge offered in some existing curricular of junior secondary school and let college student to understand more the application of solar energy. To address the ways of strengthening students' memory in this area, field trip or physical visit of the installed solar driven facilities are one of the popular option. However, it has been observed that there is also a paucity of information about structured learning design and devices, including structured pre-study exercises and post-trip knowledge reinforcement activities, in educational field trips. Also learning aids in field study are limited by the words stated on nearby display, pictures, photos and tour guides' explanation. These tools may not be easy to fasten students' attention due to the shortage of amusing and funny content. Thus, the study aims to initiate the conceptualization of the solar knowledge delivery via educational tourism and edutainment approach based on literal support. Specifically, the project consults educational theories and adapt the edutainment approach to conceptualize field education for students. Then, the project will detail the teaching plan, amusing features and assessment design for the participants. The third objective is to assess the performance of two testing student groups that one goes through the education of the proposed informal settings and the other just have the ordinary classroom training. Two potential sites (Wanning Resort and Xian Park) with informal settings are chosen for implementing this project which consists of six stages. Literature review shows that there are some scholars' and educators' advocating planned physical outdoor environment, student action study, educational tourism and orienteering exercise as devices to enhance students' learning (Warger et al., 2009; Shamsuddin et al. 2007; Ibrahim and Fadzil,2013). The planned physical environment is bound to create higher potential for learners to achieve higher knowledge and skills. Good integration between building and outdoors spaces encourage better social interaction and intellectual culture. Besides, students demand creative and innovative space conditions possibly through the introduction of design elements that are different from the classroom standards. In the early 2000s, several studies recognized the development of educational tourism and viewed educational forms of tourism along a continuum ranging from "general interest learning" at one end to "purposeful learning and travel" at the other end (CTC, 2001; Ritchie and Coughlan, 2004). However, school excursion tourism is a relatively under-researched and poorly understood segment of the tourism industry (Ritchie et., 2008). Orienteering activity have been appealing to youngsters for decade and is a kind of sport activity that focuses on the use and interpretation of maps in outdoor environments in order to get to some checkpoints to obtain certain scores (McNeil et al., 1998; Bertril and Arne, 1991).

[28SP3X-2] Examining the Effects of Displaying Clicker Voting Results on High School Students' Conceptual Learning Outcomes: A Comparative Study between Taiwan and Japan (*A0477*)

Yu-Ta Chien*[1], Eizo Ohno[2+], Yu-Hsien Lee[1], Kohsuke Nomura[3], and Chun-Yen Chang[1+]

1. National Taiwan Normal University, Taiwan, 2. Hokkaido University, Japan, and 3. Sapporo Kaisei Secondary School, Japan

ABSTRACT Clickers are widely advocated as a useful tool to break up the passive learning format of science lectures. It is expected that the use of clickers will actively engage students in thinking about the content presented during the lecture. The common practice of using clickers is described as following: 1) Students are challenged by a conceptual question and asked to vote for their answers (i.e., the initial voting); 2) The results of initial voting are shown publicly; 3) Students discuss the question with peers and vote again (i.e., the second voting); and 4) The use of second voting creates a "teaching moment" for the teacher to clarify students' conceptions. However, the pedagogical value of showing initial voting results has been challenged as more and more schools are adopting clickers. Researchers have indicated that if the initial voting results are shown before peer discussion, students tend to passively conform to the majority's opinion, rather than actively examining the flaws of their own reasoning processes. Furthermore, if students simply conform to the majority opinion, the second voting results can give the teacher a "false" image that students' understanding has been improved through peer discussion. The teacher may thus miss the teaching moment for resolving students' learning difficulties. More attention should be paid to this issue for using clickers to promote

active learning more effectively. Therefore, this poster aims to present an on-going comparative study that explores the possible impact of showing initial voting results on students' conceptual learning outcomes. A seven-hour-long course has been implemented in both Taiwan and Japan to help high school students learn Newton's laws of motion. In both research sites, students were assigned to either the display or non-display session. The two instruction sessions were developed based on Mazur's peer instruction model. Both instruction sessions were divided into several small units. Within each unit, students were asked to use clickers to answer conceptual questions either before or after a brief lecture. After that, by initiating peer discussions, students were engaged in generating explanations to justify their own choices. Students were then given a chance to revote on their answers, followed by the teacher's explanations about why their answers were correct or not. The two instruction sessions were basically the same as each other. The only difference between sessions was that one of them displayed voting results after individual voting (i.e., the display session), but the other did not (i.e., the non-display session). A shorten version of the Force Concept Inventory (FCI) was administrated as the pre- and post-test. We got 111 valid responses from the display session (40 from Taiwan and 71 from Japan) and 105 valid responses from the non-display session (37 from Taiwan and 68 from Japan). Three major trends emerged across both research sites: 1) Compared to the non-display condition, the display condition was more helpful for students to reinforce some pieces of Newtonian thinking (i.e., maintaining the correct answers); 2) Compared to the non-display condition, the display condition was more likely to reinforce students' original non-Newtonian thinking that was activated by FCI (i.e., maintaining the same wrong answers); and 3) Compared to the display condition, the non-display condition was more likely to make students shift to other non-Newtonian ways of thinking (i.e., changing to different but wrong answers). Audio recording of Taiwanese students' peer discussion processes will be further analyzed to explain the aforementioned phenomena. Suggestions for using clickers to teach physics will then be discussed in adjunction with the results of audio analysis. A follow-up study of this poster will then be presented as well.

[28SP3X-3] An Investigation on Junior Secondary School Biology Teachers' STEM Perceptions and Practices in China Mainland (*A0222*)

Xuan Huang* and Enshan Liu+
Beijing Normal University, China Mainland

ABSTRACT STEM education has attracted worldwide attention in science education, for its significant role in preparing innovation talents. Teachers' STEM content knowledge and practical abilities have influence on the advancement of STEM education in K-12 to some extent, which makes it urgent to improve teachers' STEM professional development. The studies of teachers' STEM professional development in China mainland are just starting, so it's essential to investigate teachers' STEM perceptions and practices first, in order to promote STEM professional development programs for them. In China mainland, science curriculum in junior secondary school is mainly divided into different disciplines including biology, physics, chemistry and geography, and biology is one of the first science courses at grade 7, so our investigation will focus on junior secondary school biology teachers. The specific research questions are: (1) What are junior secondary school biology teachers' overall perceptions on STEM education in China mainland? (2) What are junior secondary school biology teachers' current practices of STEM education in China mainland? (3) What needs do junior secondary school biology teachers have for their STEM professional development in China mainland? The mixed methods will be adopted by using an autonomous developed questionnaire and a semi-structured interview outline, to investigate junior secondary school biology teachers into the following details: their perceptions of the connotation and essence of STEM education, their STEM teaching effectiveness and practical abilities and their demands for STEM professional development. The questionnaire draft has 36 items using 5 point Likert scale, which constitute three dimensions: STEM perceptions, STEM practices and STEM professional development. The expert judgment and pre-test will be employed to ensure that the questionnaire has good reliability and validity, then about 100 teachers will be selected to participate in the questionnaire investigation; the semi-structured interview is going to be conducted in accordance with five open-ended questions as an interview outline, and about 15 teachers will be selected to participate in the interview survey. To be representative, the teachers who participate in the investigation will come from different parts of China, including East China, Central China and West China, by convenient sampling. The SPSS software will be adopted to analyze quantitative data by the use of T test and one-way ANOVA, then combining the analysis of both quantitative and qualitative data to draw conclusions, and to provide suggestions to the STEM professional development of junior secondary school biology teachers.

Special Poster 3Y (28th, 11:30-12:50)

[28SP3Y-1] Study on the Guidance to Increase the Mathematical Expression Using "Tower of Hanoi" (*A0316*)

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ABSTRACT This study is intended to increase the mathematical expression of the mathematical communications to conduct activities mutually communication described as part of the language activities. The language activity in mathematics class means the following three points. 1) Express and explain mathematically such as process of thinking and judgment of the basis. 2) Interpreted by the discussion about things that have been expressed mathematically. 3) By mutually convey the idea, develop the idea of the individual or group. Specific language activities in the class is a discussion among students, such as the following. Students carry out the conversion of words and figures and expressions of representation, and determine the minimum number of movements of the tower of Hanoi. Then using a worksheet, they explain their thinking and express an opinion on the description of the thinking of others. Through this activity, increased the mathematical expression that convey an easy-to-understand their thinking to the others. I use the "Tower of Hanoi" as a teaching tool in the mathematic class. It is often used in the learning of the recurrence formula of

Japanese high school. “Tower of Hanoi” was invented by French mathematician Edouard Lucas in 1883. “Tower of Hanoi” is constituted by some disks of a different size and three sticks. First to have been stacked in descending order, it is an object to move the disk to the other stick. Rules to be transferred is moving only one disk at a time and never moving a larger one on a smaller.

[28SP3Y-2] Inquest of the Teaching Method in Educational Continuity from Primary through Early Secondary Levels (*A0528*)

Satoshi Fujinawa* and Minoru Ito
Tokyo University of Science, Japan

ABSTRACT Some students go on from elementary to secondary school with impediments known as “chuichi gap”. The impediments are due to change in school’s learning environment and teachers. Unlike in elementary schools, teachers teach one subject only in secondary schools. As one of the way, educational continuity from primary through early secondary levels has been promoted. In 2016, furthermore, Ministry of education in Japan enforce compulsory education school as new kinds of school. It is imperative to introduce educational continuity from primary through early secondary levels. This set up allows smooth transition from elementary to junior high school. To validate our proposal, we focused on the unit of direct proportion and inverse proportion in 6th and 7th grades mathematics. I considered about two points to establish a teaching method. First is investigation the curriculum in mathematic. It is demanded the curriculum to predict 9 years. There are some school to deal with it before. I compared the effectiveness of their curriculum and organized my proposal. Second is bringing in spiral learning. Course of study commentary in Japan mentioned we should organize the curriculum which depending on the stage of development and grade by repeated (spiral) with emphasis on systematic of arithmetic and mathematic. In the field of proportion and inverse proportion, learning system has to be particularly spiral. So, I suggest to import “Hooke’s law” and “Lever principle” in mathematics class. “Hooke's law” and “Lever principle” are learned in 6th and 7th grades. I thought that students can accept new contents by performing a concrete experiment. A few years later, a course of study will be changed. Connection with other subjects is even more demanding. By introducing the already learned matters in science class, I can carry out an effective lesson.

[28SP3Y-3] Examination Teaching Materials for the Ordinary Differential Equation to Increase Learning Motivation (*A0241*)

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ABSTRACT According to the present Japanese educational guidelines, it attaches importance not only to master learning skills of each subject but also to cultivate ability applying the learned skills to daily life or society.
Due to this, new teaching method crossing over boundaries among subjects will be necessary. To increase learning motivation, I focus on cooperation among subjects and relation between daily life and Mathematics. Then, We consider that ordinary differential equations (ODEs) describing models of various phenomena should be adopted in Mathematics curriculum of higher education. Differential equation was included in Course of Study from 1960 to 1989 as application of integral, but it has excluded since 1989. In the recent textbook, differential equation is treated only few pages as an additional remark. This study aims at development of teaching materials of ODEs in order to increase learning motivation by taking into account of relation between the other subjects such as physics, chemistry, etc. and usefulness of mathematics. The following four study methods will be applied. 1. Analysis of the current Japanese textbook. 2. Comparison with overseas textbooks and examinations. 3. Selection of topics for ODE which is acceptable for High school education and further having prospect for synergy effect of understanding the other fields. 4. Development of the teaching materials by noting the following things. i. The physical background of the equation and its derivation. ii. Explanation of a method for solving the equation. iii. Physical meaning of the solution and comparison with the other models. We would like to get advices and suggestions about the following points: 1. Overseas teaching materials of ODEs and focusing on daily life. 2. Improvement in our study methods.

CORRESPONDENCE TABLE OF ABSTRACT & PRESENTATION NUMBERS

A.N. & P.N.	
A0001	26O1F-1
A0003	26W1I
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A0005	28P3Y-12
A0006	28O5E-5
A0007	28P3X-28
A0008	27SS2K
A0009	26O1C-1
A0010	27O4B-1
A0011	28P3Y-3
A0012	26O2H-1
A0013	28O7H-1
A0014	26O2F-1
A0015	26O1F-2
A0016	27O3B-1
A0017	28O6F-2
A0018	27O3K-4
A0019	26O1J-4
A0021	26O1G-1
A0022	27P2X-29
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A0024	26O1G-2
A0025	28O5I-1
A0026	26P1Y-5
A0027	28O6C-1
A0028	26P1X-1
A0029	26P1Y-26
A0032	28O6A-1
A0033	26O1D-4
A0036	28P3Y-27
A0037	26P1X-4
A0038	26P1X-18
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A0040	26P1X-19
A0041	28O6E-1
A0042	26P1X-20
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A0046	26P1X-25
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A0057	28P3X-23
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A0072	28P3Y-15
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A0082	27O3I-1
A0083	26O2F-2
A0084	27W2L
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A0094	26P1Y-21
A0097	27O3D-1
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A0099	28O5J-2
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A0104	27O3E-3
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A0111	28O7I-2
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A0114	27O4F-2
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A0119	27O3G-2
A0120	26O1L-1
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A0124	28P3X-26
A0125	27P2X-22
A0126	28O5C-2
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A0135	27O3J-2
A0136	26O1K-2
A0137	27P2X-12
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A0244	26O2F-3
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A0246	26P1Y-9
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A0252	28O6K-1
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A0261	26P1Y-16
A0262	28P3Y-17
A0263	27P2Y-19
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A0267	27P2X-5
A0268	28P3X-8
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A0271	27P2X-30
A0273	27O3A-2
A0275	28O7F-1

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A0278	27SS2B	A0352	28P3Y-2	A0425	26O1E-3	A0510	27O4A-3
A0280	26D1X-7	A0353	27O4E-3	A0426	27P2Y-25	A0511	26P1X-8
A0281	26P1X-10	A0356	27O3F-2	A0427	27P2X-16	A0512	28P3Y-4
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A0302	27O4A-2	A0379	28O5K-6	A0452	28O5B-6	A0533	28P3Y-20
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A0339	27O3G-1	A0414	28P3Y-24	A0492	26W1G	A0570	28P3X-13
A0342	28O6G-3	A0415	28O5G-5	A0494	28P3Y-29	A0572	27O3C-6
A0343	26P1Y-1	A0416	28O7C-3	A0497	27O3A-5	A0573	27O4C-1
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A0345	27SS2G	A0418	26P1X-27	A0501	28O6F-3	A0575	26SP1Y-2
A0346	27O4E-4	A0419	26O1L-3	A0503	27O3D-5	A0576	28O5F-3
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A0585	26O1L-4	A0596	28O5D-4	A0606	26O1J-1	A0624	26SP1Y-4
A0587	28O7E-1	A0597	28O5D-5	A0607	27O4C-3	A0625	27P2X-7
A0588	28O7E-2	A0598	27O4C-2	A0609	27O4C-4	A0626	26W1L
A0589	28O5E-4	A0599	26O1C-3	A0610	28O6K-2		
A0590	27P2X-4	A0600	26O1J-2	A0611	27P2Y-13		
A0591	27P2X-3	A0601	28O5L-5	A0615	27SS2A		
A0592	28O7L-4	A0602	28O5C-5	A0616	27P2Y-3		

P.N. & A. N.

26D1X-1	A0293	26O1L-4	A0585	26P1X-23	A0556	27O3A-1	A0044
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26D1X-5	A0218	26O2A-2	A0443	26P1X-26	A0417	27O3A-3	A0310
26D1X-7	A0280	26O2A-3	A0442	26P1X-27	A0418	27O3A-4	A0541
26D1X-9	A0166	26O2B-1	A0159	26P1X-29	A0142	27O3A-5	A0497
26D1X-11	A0375	26O2B-2	A0183	26P1X-30	A0406	27O3B-1	A0016
26O1A-1	A0023	26O2B-3	A0509	26P1Y-1	A0343	**27O**3B-2	A0559
26O1A-2	A0062	26O2C-1	A0297	26P1Y-2	A0320	27O3B-3	A0169
26O1A-3	A0498	26O2C-2	A0458	26P1Y-3	A0290	27O3B-4	A0237
26O1A-4	A0507	26O2C-3	A0349	26P1Y-4	A0253	27O3B-5	A0483
26O1B-1	A0138	26O2E-1	A0156	26P1Y-5	A0026	27O3C-1	A0103
26O1B-2	A0542	26O2E-2	A0052	26P1Y-6	A0314	27O3C-2	A0172
26O1B-3	A0435	26O2E-3	A0368	26P1Y-7	A0370	27O3C-3	A0383
26O1B-4	A0070	26O2F-1	A0014	26P1Y-9	A0246	27O3C-4	A0413
26O1C-1	A0009	26O2F-2	A0083	26P1Y-10	A0516	27O3C-5	A0467
26O1C-2	A0078	26O2F-3	A0244	26P1Y-11	A0295	27O3C-6	A0572
26O1C-3	A0599	26O2G-1	A0076	26P1Y-12	A0147	27O3D-1	A0097
26O1C-4	A0373	26O2G-2	A0158	26P1Y-13	A0335	27O3D-2	A0350
26O1D-1	A0396	26O2G-3	A0374	26P1Y-15	A0220	27O3D-3	A0086
26O1D-2	A0403	26O2H-1	A0012	26P1Y-16	A0261	27O3D-4	A0333
26O1D-3	A0329	26O2H-2	A0108	26P1Y-18	A0066	27O3D-5	A0503
26O1D-4	A0033	26O2J-1	A0132	26P1Y-19	A0071	27O3D-6	A0560
26O1E-1	A0294	26O2J-2	A0161	26P1Y-21	A0094	27O3E-1	A0525
26O1E-2	A0404	26O2J-3	A0401	26P1Y-22	A0292	27O3E-2	A0428
26O1E-3	A0425	26O2K-1	A0045	26P1Y-23	A0389	27O3E-3	A0104
26O1E-4	A0309	26O2K-2	A0180	26P1Y-24	A0259	27O3E-4	A0192
26O1F-1	A0001	26O2K-3	A0204	26P1Y-26	A0029	27O3E-5	A0330
26O1F-2	A0015	26O2L-1	A0211	26P1Y-27	A0363	27O3E-6	A0210
26O1F-3	A0073	26O2L-2	A0398	26P1Y-28	A0366	27O3F-1	A0304
26O1G-1	A0021	26O2L-3	A0538	26P1Y-29	A0392	27O3F-2	A0356
26O1G-2	A0024	26P1X-1	A0028	26SP1Y-1	A0436	27O3F-3	A0388
26O1G-3	A0319	26P1X-2	A0431	26SP1Y-2	A0575	27O3F-4	A0489
26O1H-1	A0326	26P1X-3	A0524	26SP1Y-3	A0465	27O3F-5	A0543
26O1H-2	A0466	26P1X-4	A0037	26SP1Y-4	A0624	27O3F-6	A0058
26O1H-3	A0198	26P1X-5	A0577	26SS1A	A0229	27O3G-1	A0339
26O1H-4	A0248	26P1X-6	A0360	26SS1B	A0518	27O3G-2	A0119
26O1I-1	A0118	26P1X-7	A0061	26SS1D	A0479	27O3G-3	A0301
26O1I-2	A0162	26P1X-8	A0511	26SS1E	A0344	27O3G-4	A0574
26O1I-3	A0551	26P1X-9	A0123	26SS1K	A0160	27O3G-5	A0604
26O1I-4	A0300	26P1X-10	A0281	26W1C	A0378	27O3H-1	A0605
26O1J-1	A0606	26P1X-11	A0088	26W1F	A0056	27O3H-2	A0175
26O1J-2	A0600	26P1X-12	A0208	26W1G	A0492	27O3H-3	A0277
26O1J-3	A0205	26P1X-13	A0209	26W1H	A0101	27O3H-4	A0593
26O1J-4	A0019	26P1X-14	A0391	26W1I	A0003	27O3H-5	A0527
26O1K-1	A0067	26P1X-15	A0566	26W1J	A0165	27O3I-1	A0082
26O1K-2	A0136	26P1X-16	A0308	26W1L	A0626	27O3I-2	A0440
26O1K-4	A0139	26P1X-17	A0085	27D2X-1	A0202	27O3I-3	A0439
26O1L-1	A0120	26P1X-18	A0038	27D2X-3	A0236	27O3I-4	A0438
26O1L-2	A0260	26P1X-19	A0040	27D2X-5	A0595	27O3I-5	A0054
26O1L-3	A0419	26P1X-20	A0042	27D2X-7	A0476	27O3I-6	A0407
		26P1X-21	A0242	27D2X-9	A0245	27O3J-1	A0372

27O3J-2	A0135	27P2X-10	A0249	28O5A-5	A0523	28O6B-2	A0456
27O3J-3	A0312	27P2X-11	A0255	28O5B-1	A0074	28O6B-3	A0487
27O3J-4	A0376	27P2X-12	A0137	28O5B-2	A0214	28O6B-4	A0555
27O3J-5	A0397	27P2X-13	A0087	28O5B-3	A0322	28O6C-1	A0027
27O3J-6	A0461	27P2X-14	A0122	28O5B-4	A0323	28O6C-2	A0151
27O3K-1	A0463	27P2X-15	A0545	28O5B-5	A0347	28O6C-3	A0580
27O3K-2	A0230	27P2X-16	A0427	28O5B-6	A0452	28O6C-4	A0568
27O3K-3	A0154	27P2X-17	A0233	28O5C-1	A0177	28O6D-1	A0055
27O3K-4	A0018	27P2X-18	A0287	28O5C-2	A0126	28O6D-2	A0328
27O3K-5	A0247	27P2X-19	A0537	28O5C-3	A0455	28O6D-3	A0486
27O3K-6	A0399	27P2X-20	A0532	28O5C-4	A0558	28O6D-4	A0163
27O3L-1	A0315	27P2X-21	A0540	28O5C-5	A0602	28O6E-1	A0041
27O3L-2	A0332	27P2X-22	A0125	28O5D-1	A0065	28O6E-2	A0583
27O3L-3	A0129	27P2X-23	A0337	28O5D-2	A0603	28O6E-3	A0549
27O3L-4	A0131	27P2X-24	A0098	28O5D-3	A0336	28O6F-1	A0517
27O3L-5	A0227	27P2X-26	A0134	28O5D-4	A0596	28O6F-2	A0017
27O4A-1	A0077	27P2X-27	A0266	28O5D-5	A0597	28O6F-3	A0501
27O4A-2	A0302	27P2X-28	A0283	28O5D-6	A0206	28O6F-4	A0429
27O4A-3	A0510	27P2X-29	A0022	28O5E-1	A0534	28O6G-1	A0143
27O4A-4	A0474	27P2X-30	A0271	28O5E-2	A0482	28O6G-2	A0235
27O4B-1	A0010	27P2Y-1	A0567	28O5E-3	A0584	28O6G-3	A0342
27O4B-2	A0223	27P2Y-3	A0616	28O5E-4	A0589	28O6G-4	A0508
27O4B-3	A0157	27P2Y-8	A0380	28O5E-5	A0006	28O6H-2	A0459
27O4C-1	A0573	27P2Y-10	A0553	28O5E-6	A0207	28O6H-3	A0334
27O4C-2	A0598	27P2Y-11	A0174	28O5F-1	A0371	28O6H-4	A0081
27O4C-3	A0607	27P2Y-12	A0004	28O5F-2	A0488	28O6I-1	A0127
27O4C-4	A0609	27P2Y-13	A0611	28O5F-3	A0576	28O6I-2	A0258
27O4D-1	A0251	27P2Y-14	A0102	28O5F-4	A0185	28O6J-1	A0153
27O4D-2	A0265	27P2Y-16	A0424	28O5F-5	A0581	28O6J-2	A0409
27O4D-3	A0311	27P2Y-17	A0544	28O5G-1	A0149	28O6J-3	A0422
27O4D-4	A0286	27P2Y-19	A0263	28O5G-2	A0305	28O6K-1	A0252
27O4E-1	A0522	27P2Y-20	A0068	28O5G-3	A0348	28O6K-2	A0610
27O4E-2	A0520	27P2Y-21	A0395	28O5G-4	A0384	28O6K-3	A0464
27O4E-3	A0353	27P2Y-23	A0617	28O5G-5	A0415	28O6L-1	A0238
27O4E-4	A0346	27P2Y-24	A0228	28O5G-6	A0470	28O6L-2	A0594
27O4F-1	A0113	27P2Y-25	A0426	28O5H-1	A0288	28O6L-3	A0462
27O4F-2	A0114	27P2Y-26	A0145	28O5H-2	A0578	28O7B-1	A0144
27O4F-3	A0296	27P2Y-27	A0105	28O5H-3	A0313	28O7B-2	A0307
27O4F-4	A0217	27P2Y-28	A0433	28O5H-4	A0200	28O7B-3	A0411
27O4H-1	A0225	27P2Y-29	A0269	28O5H-5	A0362	28O7B-4	A0112
27O4H-2	A0178	27P2Y-30	A0514	28O5I-1	A0025	28O7C-1	A0361
27O4H-3	A0298	27SP2X-1	A0471	28O5I-2	A0091	28O7C-2	A0385
27O4H-4	A0243	27SP2X-2	A0256	28O5I-3	A0116	28O7C-3	A0416
27O4I-1	A0437	27SP2X-3	A0369	28O5I-5	A0221	28O7C-4	A0457
27O4I-2	A0289	27SP2Y-1	A0364	28O5I-6	A0565	28O7D-2	A0454
27O4I-3	A0382	27SP2Y-2	A0140	28O5J-1	A0090	28O7D-3	A0562
27O4J-1	A0306	27SP2Y-3	A0234	28O5J-2	A0099	28O7E-1	A0587
27O4J-2	A0212	27SP2Y-4	A0179	28O5J-3	A0060	28O7E-2	A0588
27O4J-3	A0554	27SS2A	A0615	28O5J-4	A0448	28O7E-3	A0203
27O4J-4	A0226	27SS2B	A0278	28O5J-5	A0552	28O7F-1	A0275
27O4K-1	A0128	27SS2E	A0446	28O5K-1	A0550	28O7F-2	A0170
27O4K-2	A0130	27SS2G	A0345	28O5K-2	A0515	28O7F-3	A0513
27O4K-3	A0393	27SS2K	A0008	28O5K-3	A0359	28O7F-4	A0291
27O4L-1	A0194	27W2C	A0504	28O5K-4	A0047	28O7G-1	A0402
27O4L-2	A0257	27W2D	A0531	28O5K-5	A0453	28O7G-2	A0469
27O4L-3	A0505	27W2F	A0110	28O5K-6	A0379	28O7G-3	A0548
27P2X-1	A0521	27W2H	A0152	28O5L-1	A0215	28O7G-4	A0561
27P2X-2	A0475	27W2I	A0250	28O5L-2	A0224	28O7H-1	A0013
27P2X-3	A0591	27W2J	A0039	28O5L-3	A0405	28O7H-3	A0381
27P2X-4	A0590	27W2L	A0084	28O5L-5	A0601	28O7I-1	A0106
27P2X-5	A0267	28O5A-1	A0089	28O6A-1	A0032	28O7I-2	A0111
27P2X-7	A0625	28O5A-2	A0547	28O6A-2	A0239	28O7I-4	A0216
27P2X-8	A0232	28O5A-3	A0303	28O6A-4	A0069	28O7L-1	A0064
27P2X-9	A0254	28O5A-4	A0167	28O6B-1	A0421	28O7L-2	A0231

28O7L-3	A0530	28P3X-16	A0351	28P3Y-6	A0053	28P3Y-24	A0414
28O7L-4	A0592	28P3X-17	A0423	28P3Y-8	A0043	28P3Y-25	A0623
28P3X-1	A0519	28P3X-18	A0299	28P3Y-9	A0377	28P3Y-26	A0408
28P3X-2	A0480	28P3X-22	A0621	28P3Y-10	A0063	28P3Y-27	A0036
28P3X-3	A0569	28P3X-23	A0057	28P3Y-11	A0526	28P3Y-28	A0410
28P3X-4	A0201	28P3X-24	A0080	28P3Y-12	A0005	28P3Y-29	A0494
28P3X-5	A0107	28P3X-25	A0365	28P3Y-13	A0133	28P3Y-30	A0445
28P3X-6	A0115	28P3X-26	A0124	28P3Y-14	A0150	28SP3X-1	A0213
28P3X-7	A0582	28P3X-27	A0199	28P3Y-15	A0072	28SP3X-2	A0477
28P3X-8	A0268	28P3X-28	A0007	28P3Y-16	A0444	28SP3X-3	A0222
28P3X-9	A0324	28P3X-29	A0321	28P3Y-17	A0262	28SP3Y-1	A0316
28P3X-10	A0164	28P3X-30	A0420	28P3Y-18	A0050	28SP3Y-2	A0528
28P3X-11	A0539	28P3Y-1	A0394	28P3Y-19	A0432	28SP3Y-3	A0241
28P3X-12	A0484	28P3Y-2	A0352	28P3Y-20	A0533		
28P3X-13	A0570	28P3Y-3	A0011	28P3Y-21	A0390		
28P3X-14	A0264	28P3Y-4	A0512	28P3Y-22	A0282		
28P3X-15	A0270	28P3Y-5	A0434	28P3Y-23	A0284		

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