E·A·S·E 2011

East-Asian Association for Science Education

Lighting the World with Science

EASE International Conference
October 25-29, 2011

Chosun University, Gwangju, KOREA

CONFERENCE PROCEEDINGS

E·A·S·E 2011

EASE 2011 International Conference, Chosun University, Gwangju, Korea, October 25-29, 2011

Lighting the World with Science

EDITORS:
- Youngmin Kim (Pusan National University)
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- Ji-Ae Lee (Pusan National University)
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YEAR OF PUBLISHING: 2011 October

ORGANIZER & CO-ORGANIZERS:
- East-Asian Association for Science Education
- Korean Association for Science Education
- Korean Elementary Science Education Society
- Chosun University
- Science Education for the Next Society, Seoul National University
- Research Institute for Science Education of Pusan National University
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- Korea Foundation for the Advancement of Science and Creativity
- Korean Federation of Science and Technology Societies
- Korean Federation of Science Education Societies
- College of Education, Chosun University
- Research Institute for Subject Matter Education, Chosun University
- Global Institute for STS Education, Ewha Womans University
- Korea Tourism Organization

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WELCOME MESSAGE

Dear Colleagues,

It is great pleasure to invite EASE members and other science educators for the EASE 2011 International Conference to be held in the city of light, Gwangju (光洲), Korea. Gwangju Metropolitan City is located in the southwest corner of the Korean peninsula and is internationally well known for its beautiful mountains and intangible cultural assets. We are sure that you will enjoy Korea's traditions and beauties.

The theme of EASE 2011 International Conference is "Lighting the world with science." In order to encourage more active participation of the EASE members and educators, we provide ten different strands in science education and offer different formats of sessions including oral and poster presentations, invited speeches, special concurrent sessions, and cultural visits.

We hope that EASE 2011 International Conference becomes a place where you can share your research interest, build relationships with other colleagues, and taste Gwangju. We look forward to meeting you in the City of Light in October 2011.

Sincerely,

Byeongsoon Choi
Chair of Organizing Committee
Korea National University of Education

Youngmin Kim
Conference Coordinating Chair
Pusan National University

GENERAL INFORMATION

OVERVIEW OF EASE CONFERENCE 2011

- Theme
  Lighting the world with science
- Conference dates
  October 25-29, 2011
- Venue
  Chosun University, Gwangju, Korea

EASE 2011 COMMITTEE : LOCAL

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- Assistants
  Jung-Hoon Kim, Heon-Sam Yang, Yoo-Jin Kim

INFORMATION

STRAND

1. *Teaching and Learning Science in Schools*
2. *Teaching and Learning Science in Informal Settings*
3. *ICT and Science Education*
4. *Teaching Scientific Creativity*
5. *Professional Development Program for Science Teachers*
6. *History and Philosophy for Science Education*
7. *Assessment and Evaluation in Science Education*
8. *Teaching Science at College Level*
9. *Regional Science Education*
10. *Socio-Scientific Issues and Human Values in Science Education*

GUIDELINE

GUIDELINES FOR CHAIRING A SESSION

The following guidelines for chairing sessions at EASE 2011 are provided to ensure a smooth running conference.

- Meet with all your speakers 10 minutes before the start of your session. At that time, make needed introductions and help them feel comfortable with the room arrangements and fellow participants.
- Describe to your speakers the method you will use to notify them when they are nearing their presentation time limit and how you will interrupt them if they have reached the end of their allotted time.
- At 13 minutes of a 20-minute talk, give a 'first signal' to the speaker and 'second signal' at 15 minutes. Adjust for longer presentations.
- At 18 minutes of a 20-minute talk, give a 'sign' to the speaker for 'questions and answers.'

GUIDELINES FOR ORAL PRESENTATION

Three up to five presentations are assigned into each session of total 60 minutes or 100 minutes. The papers will be grouped by theme.

- 20 minutes including 5 minutes for Q&A will be provided for each oral presentation.
- LCD projector and computer will be provided. (If you use Mac, you need to make your own arrangement)
- Authors are preferred to preparing for the hard copies of presentation available for dissemination.

GUIDELINES FOR POSTER PRESENTATION

All the posters must be prepared on individually assigned poster boards on the first floor main room. Poster presentation times are as follows:

- Poster Session 1-A, B (Wed) 14:20 - 15:20, the posters need to be prepared before 14:00
- Poster Session 2-A, B (Thu) 14:40 - 15:40, the posters need to be prepared before 14:20
- Poster Session 3-A, B (Fri) 11:00 - 12:00, the posters need to be prepared before 10:40

After presentations, all the posters must be removed from the poster boards. Available space on a poster board is 90cm × 120cm. No power supply is available at the poster board. The poster presenters who wish to use personal computers are requested to charge their batteries before the presentation.

VENUE

CHOSUN UNIVERSITY (朝鮮大學校)

INTRODUCTION

Chosun University is one of the oldest and most prestigious private universities in Korea. Its campus is situated in Gwangju metropolitan city, in the southwestern corner of Korea.

Administrative building

EASE 2011 INTERNATIONAL CONFERENCE

We are pleased to host the EASE 2011 International Conference here and we hope all of you have exotic and special experiences in view, food, and weather of Korea during your stay in Gwangju.

Haeoreumgwan, theater.

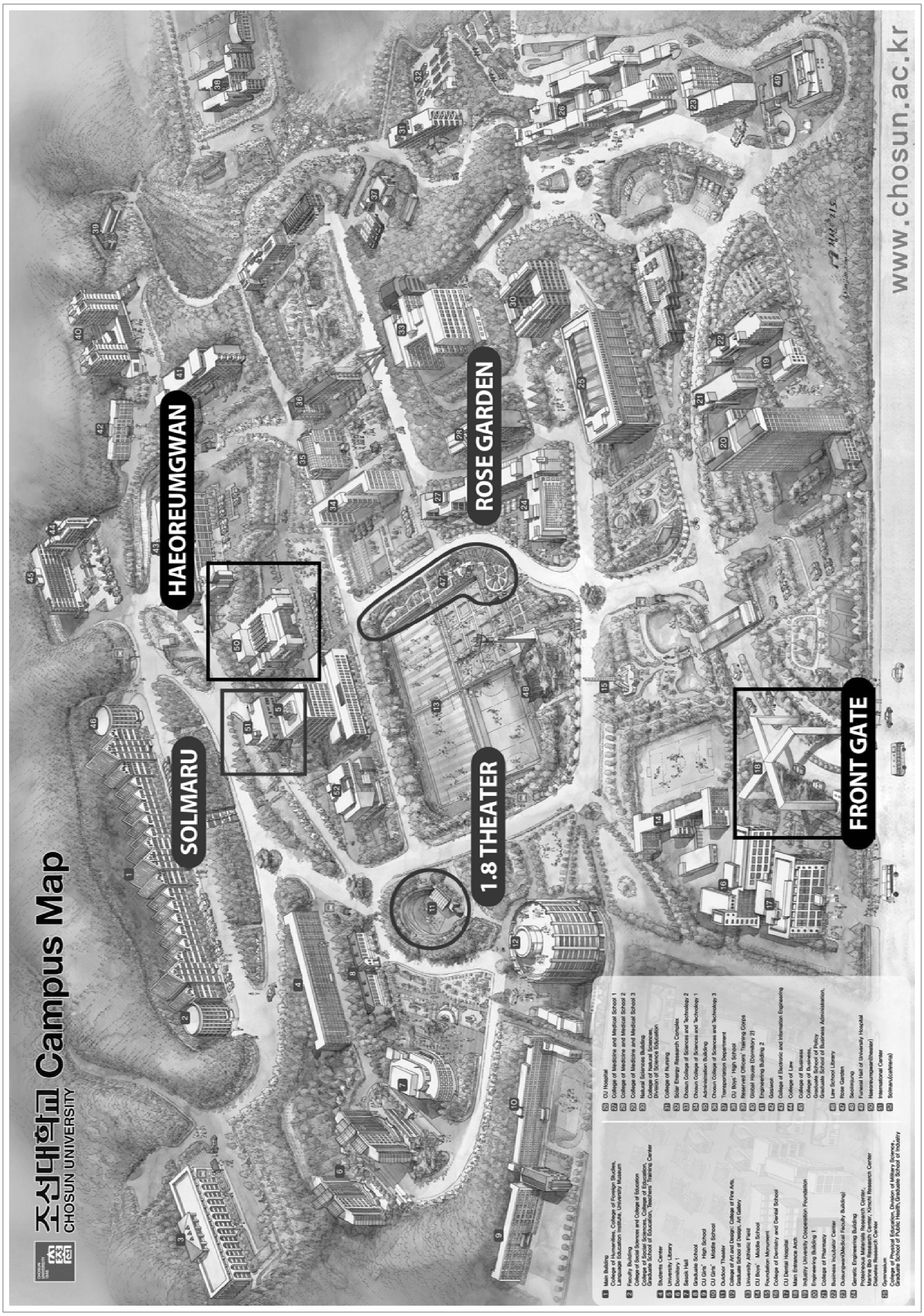
Solmaru, cafeteria. It was founded in November 2010.

We will have EASE 2011 International Conference in these two buildings; you can refer to the Campus Map.

In the campus you can find the “Haeoreumgwan” (Sun Rising building #51) which is under construction and will be completed on this coming August 2011. You can enjoy EASE 2011 International Conference in new building. We will have most of activities and events in this building.

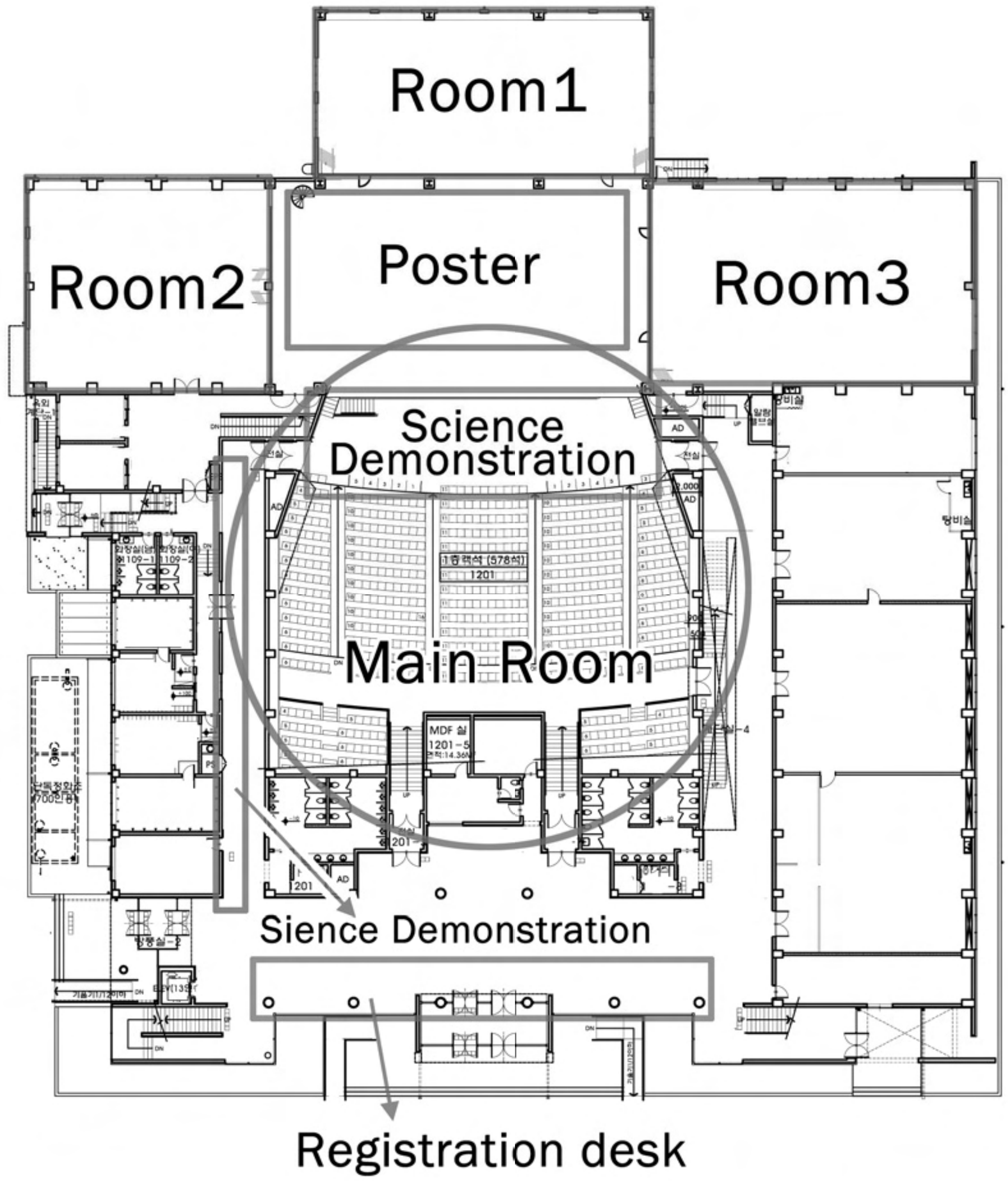
You can find another building, Solmaru (Pine trees area), which is cafeteria for having your food and relaxing yourselves at balcony with great weather in autumn season.

CAMPUS MAP

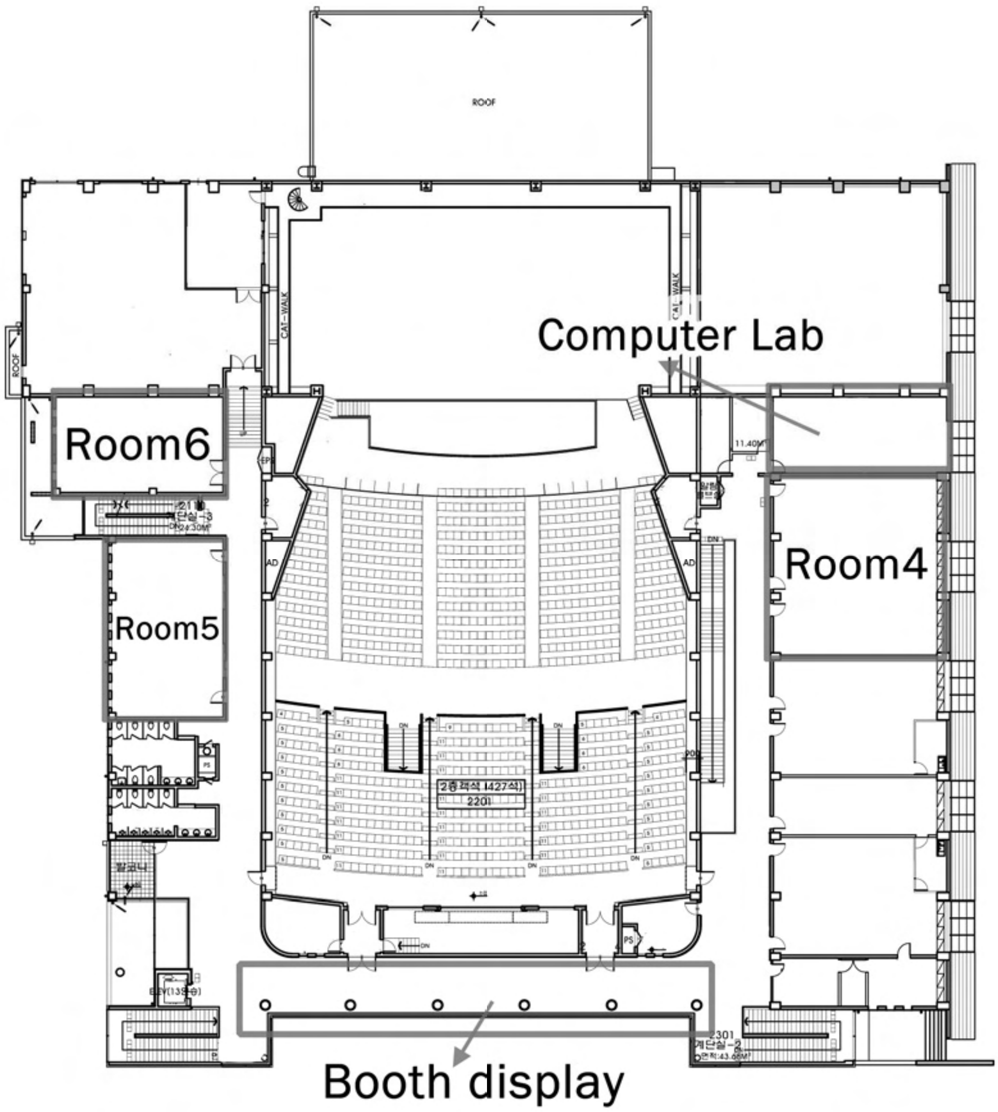


조선대학교 Campus Map
CHOSUN UNIVERSITY
www.chosun.ac.kr
HAEOREUMGWAN
ROSE GARDEN
SOLMARU
1.8 THEATER
FRONT GATE

FLOOR PLAN: LOBBY LEVEL



FLOOR PLAN: SECOND LEVEL



INVITED SPEAKER

STEVE CHAPMAN

Steve Chapman is a lecturer in science education at the Institute of Education, University of London, where he teaches pre-service physics and science teachers and also on the MA in science education. He also works for the Science Learning Centre, London working with teachers to support their physics knowledge. Steven's research interests are about teaching physics in informal environments like science centres and museums. In particular research on the barriers to teaching in such an environment, learning in hands-on galleries and wonder in museums. He is also looking at the impact of CPD in supporting non-specialist teachers. Before working as an academic Steven worked as a teacher, a government scientist and was education manager for the British Association for the Advancement of Science (now the British Science Association) and the Institute of Physics. He has a BSc in astronomy and a DPhil in low-temperature physics. Steven was on the editorial board of Physics Education for 8 years and is on the advisory panel for Educational Research. Steven consults for a number of organizations including broadcasters, research organizations, think-tanks and the UK government. When not working or looking after his children he is probably asleep.

JUSTIN DILLON

Justin Dillon is a Professor of Science and Environmental Education and Head of the Science and Technology Group at King's College London. After completing a degree in chemistry, he taught in London schools for 9 years before joining King's in 1989. Justin's research interests include teaching and learning in schools, museums, science centres and in the outdoor classroom and is involved in a 5-year ESRC longitudinal study of 10-14-year-old students' interests and aspirations in science (Aspires). He is one of the co-ordinators of the Targeted Research Initiative in Science and Mathematics Education funded by a range of bodies including the ESRC, DfE, IoP, ASE and the Gatsby Foundation. Justin is evaluating an EU-funded project, "Towards Women in Science and Technology" (TWIST) which involves science centres in several countries. In 2007, Justin was elected President of the European Science Education Research Association and he co-edits the International Journal of Science Education.

BRIAN HAND

Brian Hand is a Professor of Science Education at the University of Iowa. He received Ph. D. from the Curtin University. His research focuses on two major areas. The first is on how we can use language as a learning tool to improve students' understanding of science. His work has focused on using writing as a learning tool and is now moving to focus on the use of multi-modal representation within science classrooms. This research extends the use of writing as a learning tool to include different modes of representation. The second area of research is the development of scientific argument through the use of the Science Writing Heuristic (SWH). This research is aimed at helping students learn about and use science argument to construct science knowledge. He published research in the areas of writing to learn science and argument based inquiry approaches to learning of science.

FUJII HIROKI

Fujii Hiroki is an associate professor of science education in Graduate School of Education at Okayama University, Japan. He graduated from Hiroshima University and obtained a teacher qualification in chemistry in 1990. After studying at Institute for Science Education (IPN) of University of Kiel (Germany) in 1994, he held a Ph. D. in science education. His major area of work is design and development of school science (chemistry) curricula and lessons to promote student's scientific literacy by using international comparative approach.

SHINHO JANG

Shinho Jang is an associate professor of Science Education in Seoul National University of Education, Korea. His current research involves understanding science teachers' teaching practice and knowledge, and providing students with various inquiry programs through informal outreach learning context.

JOSEPH KRAJCIK

Joseph Krajcik is a Professor of Science Education in the School of Education at the University of Michigan and serves as the School's Associate Dean for Research. He is also Co-Director of the IDEA (Instructional Development and Education Assessment) Institute at the university. He is also a co-principle investigator for the Institute for Global Science, Technology and Society Education at Ewha Womans University in Seoul. He received his Ph. D. from the University of Iowa in 1986 and joined the faculty of the University of Michigan in 1990. His research involves working with science teachers and school systems to create classrooms where students are actively doing the intellectual work by finding solutions to intellectual questions. In addition to his work with the IDEA Institute, He is the principal investigator of a materials development project that aims to design, develop and test the next generation of middle school curriculum materials. He currently is co-editor of the Journal of Research in Science Teaching. He has authored and co-authored over 100 manuscripts and makes frequent presentations at international, national and regional conferences that focus on his research as well as presentations that translate research findings into classroom practice. His honors include the Distinguished Contributions to Science Education Through Research Award from the National Association of Research in Science Teaching (NARST) (2010), John H. D'Arms Faculty Award for Distinguished Graduate Mentoring from the University of Michigan (2010), an appointment as Distinguished Professor, Ewha Womans University, Seoul, South Korea (2009); induction as a Fellow of the American Educational Research Association (2009).

LINGBIAO GAO

Lingbiao Gao is a Deputy Head of the MOE Centre of Curriculum Studies in Basic Education, South China Normal University. He held a Ph. D. in Psychology/Science Education at the University of Hong Kong. His research areas are Science Education/Environmental Education, Curriculum Development/Evaluation, and Classroom Learning/Teaching. He is a member of the National Commission of Experts on Curriculum and Teaching Materials in Basic Education, 2010-2013, and chairman of the Physics Teachers' Association, Guangdong Province, P. R. China. He has authored and co-authored over 180 papers, book chapters and books have been published since 1981. His books include How to Assess Senior Secondary Students' Achievement under the New National Curriculum (in Chinese)；Beijing: Higher Education Press，2005; A study of Chinese teachers' conceptions of teaching (in English); Wuhan: Hubei Education Press, 2004.

CHIA-JU LIU

Chia-Ju Liu is currently the chairperson of Graduate Institute of Science Education, the director of Science Education Center and the director of Neurocognition Laboratory at National Kaohsiung Normal University in Taiwan. Her research interests are conceptual change and learning processes, scientific thinking, cognitive psychology in science education, experimental research design in cognitive psychology, and neuropsychology and science learning. Currently, her research group is investigating multiple representations in science education, and visual and spatial Modes in science education by ERPs and eye tracking techniques. This group also cooperates with Kaohsiung Veterans General Hospital to explore the early diagnosis of some brain dysfunctions.

MICHAEL R. MATTHEWS

Michael R. Matthews is an associate professor in the School of Education at the University of New South Wales. He has degrees in Geology, Psychology, Philosophy, History and Philosophy of Science, and Education. He has taught in high school, Teacher's College and universities, and was Foundation Professor of Science Education at the University of Auckland. His books include Science Teaching: The Role of History and Philosophy of Science (Routledge 1994); Time for Science Education: How Teaching the History and Philosophy of Pendulum

Motion can Improve Science Literacy (Plenum Publishers 2000). His edited books include Constructivism in Science Education: A Philosophical Examination (Kluwer Academic Publishers 1998); Science Education and Culture (Kluwer Academic Publishers 2001); The Pendulum: Scientific, Historical, Philosophical and Educational Perspectives (Springer 2005) and Science, Worldviews and Education (Springer2009). He is Foundation Editor of the journal Science & Education; he has published scores of articles in science education, philosophy of education and the history and philosophy of science journals; he has contributed to major Education encyclopedias and handbooks. He is President of the Teaching Commission of the Division of History of Science and Technology of the International Union of History and Philosophy of Science. He was Foundation President of the International History, Philosophy and Science Teaching Group.

JONGWON PARK

Jongwon Park is a professor of physics education department in Chonnam National University, Korea, a past-chief editor of the 'Journal of The Korean Association in Science Education', and a direct of the 'Center for the Gifted in Science' in his university. His major research concerns are to understand and to model students' mental processes when they perform scientific research and construct scientific concepts, such as, mental model of scientific observation, thinking strategies for finding research problems, similarity-based reasoning model for generating scientific hypothesis, interpretation of students' hypothesis testing based on the philosophy of science. His research results can be found in international journals including IJSE, RISE and JRST. And also, for teaching creativity in science classroom, he recently suggested a 3-dimensional model of scientific creativity and developed concrete teaching materials for improving students' scientific creativity.

DAVID TREAGUST

David Treagust is a Professor of Science Education at Curtin University in Perth, Western Australia where he teaches courses in campus-based and international pro-

grams related to teaching and learning science. His research interests include understanding students' ideas about science concepts and how these ideas relate to conceptual change, the design of curricula and teachers' classroom practices. Particularly, he is interested in identification, design and implementation of intervention strategies to challenge students' conceptions; design of tests and other assessment instruments to diagnose student understanding of content in specific science areas; students' use of analogies and models as an aid to their understanding of science concepts. He is a member of the Australian National Advisory Committee for Program for International Student Assessment, a Past-President of the National Association for Research in Science Teaching (1999-2001), and Past-Managing Director of the Australasian Science Education Research Association (2003-2010).

PROGRAM

PROGRAM AT GLANCE

Tuesday, October 25, 2011						
18:00-21:00	Social Icebreaker					Solmaru (Cafeteria)

Wednesday, October 26, 2011						
08:30-09:00	Registration					Lobby
09:00-09:40	Opening Ceremony					Main Room
09:40-10:40	Plenary Session [David Treagust]					Main Room
10:40-11:00	Coffee Break					Lobby
11:00-12:00	Invited Speech 1 [Shinho Jang] Room2			Invited Speech 2 [Lingbiao Gao] Room3		
12:00-13:00	Lunch (Lunch Box)					Main Room
13:00-14:00	Invited Speech 3 [Brian Hand] Room2			Invited Speech 4 [Michael Matthews] Room3		
14:00-14:20	Coffee Break					Lobby
14:20-15:20	*P1-A Main Room	P1-B Main Room		*SD1-A Main Room	SD1-B Lobby	
15:10-15:20	Coffee Break					Lobby
15:20-16:20	*IW1 [Hiroki Fujii, Haruo Ogawa] Room1	IW2 [Steven Chapman] Room2		*CW1 Room3	CW2 Room4	CW3 Room5
16:20-16:40	Coffee Break					Lobby
16:40-18:20	*O1-A Room1	O1-B Room2	O1-C Room3	O1-D Room4	O1-E Room5	O1-F Room6
19:00-21:00	EASE Executive Board Meeting					

Thursday, October 27, 2011						
08:30-09:00	Registration					Lobby
09:00-10:00	Invited Speech 5 [Justin Dillon] Room2			Invited Speech 6 [Joseph Krajcik] Room3		
10:00-10:20	Coffee Break					Lobby
10:20-11:40	O2-A Room1	O2-B Room2	O2-C Room3	O2-D Room4	O2-E Room5	O2-F Room6
11:40-11:50	Break					
11:50-12:20	EASE General Assembly					Main Room
12:20-13:20	Lunch (Lunch Box)					Main Room
13:20-14:20	O3-A Room1	O3-B Room2	O3-C Room3	O3-D Room4	O3-E Room5	O3-F Room6
14:20-14:40	Break					
14:40-15:40	P2-A Main Room	P1-B Main Room		SD2-A Main Room	SD2-B Lobby	
15:40-16:40	IW3 [Chiaju Liu] Room1	CW4 Room2	CW5 Room3	CW6 Room4	CW7 Computer Lab	
16:40-17:00	Coffee Break					Lobby
17:00-18:40	O4-A Room1	O4-B Room2	O4-C Room3	O4-D Room4	O4-E Room5	O4-F Room6
18:40-19:00	Moving to Conference Banquet Venue					
19:00-21:00	Conference Banquet					Gwangju Rammada Plaza Hotel

Friday, October 28, 2011						
08:30-09:00	Registration					Lobby
09:00-10:00	O5-A Room1	O5-B Room2	O5-C Room3	O5-D Room4	O5-E Room5	O5-F Room6
10:00-10:20	Coffee Break					Lobby
10:20-11:00	IW4 [Jongwon Park] Room1	Regional Special Session Room2		CW8 Room3	CW9 Room4	CW10 Room5
11:00-12:00	P3-A Main Room	P3-B Main Room		SD3-A Main Room	SD3-B Lobby	
12:00-13:00	Lunch					Solmaru (Cafeteria)
13:00-14:20	O6-A Room1	O6-B Room2	O6-C Room3	O6-D Room4	O6-E Room5	O6-F Room6
14:20-14:30	Break					
14:30-15:00	Closing Ceremony					Main Room
15:00-	Educational Visiting					

Saturday, October 29, 2011	
09:00-	Cultural Visiting

* **O:** Oral Presentations; **P:** Poster Exhibition; **IW:** Invited Workshop; **CW:** Contributed Workshop; **SD:** Science Demonstration

PROGRAM

Tuesday, October 25, 2011 — *Venu: Solmaru*

18:00-21:00 **Social Icebreaker** — *Solmaru (Cafeteria)*

Wednesday, October 26, 2011 — *Venu: Haeoreumgwan*

08:30-09:00 **Registration** — *Lobby*

09:00-09:40 **Opening Ceremony** — *Main Room*

chair: Young-Shin Park (Chosun University, Korea)

Opening Address: Byung Soon Choi (Chair, Organizing Committee)
Congratulatory Address : Jong Yoon Park (President, Korean Association of Science Education), Byung-Ghi Jang (President, Korean Society of Elementary Science Education), Jinwoong Song (President, EASE)
Words of Encouragement: Ho Jong Jeon (President, Chosun University, Korea)

09:40-10:40 **Plenary Session** *(p. 30)* — *Main Room*

chair: Masakata Ogawa (Tokyo University of Science, Japan)

Why is an Understanding of Multiple Representations so Important in Learning Science?
David Treagust (Curtin University, Australia)

10:40-11:00 **Coffee Break** — *Lobby*

11:00-12:00 **Invited Speech 1** *(p. 36)* — *Room2*

chair: Sung-Tao Lee (National Taichung University of Education, Taiwan)

Building a Community of Practice for Facilitating Informal Scientific Inquiry Activities in Korea
Shinho Jang (Seoul National University of Education, Korea)

Invited Speech 2 *(p. 42)* — *Room3*

chair: Sunyoung Kim (Chosun University, Korea)

A Review on Primary School Science Textbook in China: Features and perceptions of students and teachers
Lingbiao Gao (South China Normal University, China Mainland)

12:00-13:00 **Lunch (Lunch box)** — *Main Room*

13:00-14:00 **Invited Speech 3** *(p. 45)* — *Room2*

chair: Alice S. L. Wong (The University of Hong Kong, Hong Kong)

An Immersion Approach to Argument Based Inquiry – Does It Look the Same in Different Countries?
Brian Hand (University of Iowa, USA)

Invited Speech 4 *(p. 55)* — *Room3*

chair: Hye-Gyoung Yoon (Chuncheon National University of Education, Korea)

Lighting the World with Science: Lessons from the Role of Science in the European Enlightenment
Michael R. Matthews (University of New South Wales, Australia)

14:00-14:20 **Coffee Break** — *Lobby*

14:20-15:20 **Poster Exhibition 1-A** *(p. 92)* — *Main Room*

P1-A1 Application of Problem-Based Projects to Increase Meaning-Making in the Science Classroom
Highmy Herbers*, Chang Seob Kwon, Sukkyoo Lee, Jung Hoon Ahn, In Jeong Ko, Kwang Il Kang (Korea Science Academy of KAIST, Korea)

P1-A2 Analysis of Verbal Interaction on the Process of Elementary Students' Hypothesis Generation Learning
Hee-Young Park, Il-Sun Lee*, Won-Jung Kim, Yong-Ju Kwon (Korea National University of Education, Korea)

P1-A3 A Study of Designing Science Toys into Science Instruction for 4th Graders
Ching-san Lai*, Fang-chu Wang[1] (National Taipei University of Education, Taiwan), (Ze-hsin Elementary School, Taiwan)[1]

P1-A4 A Study of Project-Based Learning on the Unit of Electric Circuit for 4th Graders
Ching-san Lai*, Shu-yuan Lin[1] (National Taipei University of Education, Taiwan), (Wen-de Elementary School, Taiwan)[1]

P1-A5 Comparative Study of Trends and Patterns within the Test Content between Junior High School Science Textbooks and Ehime Prefecture's High School Entrance Examination
Takekuni Yamaoka*, Manabu Sumida[1], Hayashi Nakayama[2] (Yuge Upper Secondary School, Japan), (Ehime University, Japan)[1], (University of Miyazaki, Japan)[2]

P1-A6 Mathematics Puzzle as an Effective Advance Organizer for Mathematics Learning
Hisato Mizushima*, Akihiko Shimano, Haruka Bungo, Marina Umeda, Soichiro Nagaya (Graduate School of Tokyo University of Science, Japan)

Wednesday, October 26, 2011 — Venu: Haeoreumgwan

14:20-15:20

P1-A7 Inventive Thinking Skills at an Early Age: Comparison between Malaysia and Brunei
Kamisah Osman*, Maria Abdullah[1] (The National University of Malaysia, Malaysia), (MOE, Brunei Darussalam)[1]

P1-A8 Grade 10 Students' Concepts About Atomic Structure
Anusit Kueakool*, Pattamaporn Pimthong (Khon Kean University, Thailand)

P1-A9 Discussion of Teaching methods about the Theory of Relativity in Physics in Busan Science High School
Jeonghoon Hwang*, Youngmin Kim (Pusan National University, Korea)

P1-A10 The Characteristics of Perceptual Change in the Nature of Science of Students Studying Arts through Explicit Instructions
Hee Jung Kim*, Sung-Won Kim (Ewha Womans University, Korea)

P1-A11 The Impact of Multimodal Representation-Based Lesson on High School Students' Understanding of Science Concept and Embeddedness of Multimodal Representation in Writing
Youngho Nam*, Jeonghee Nam, Hye Sook Cho (Pusan National University, Korea)

P1-A12 A Study of Using Newspaper in Education into Science Learning for 6th Graders
Ching-san Lai*, Yun-fei Wang[1] (National Taipei University of Education, Taiwan), (Taoyuan Zhuang-Jing Elementary School, Taiwan)[1]

P1-A13 Promoting 5th Grade Students' Scientific Concept Construction, Reasoning and Inquiry through Scientific Inquiry Instruction
Chun-Tien Chen, Hsiao-Ching She, Wen-Chi Chou* (National Chiao Tung University, Taiwan)

P1-A14 Experimental Studies Aimed at Teaching New Course of Study in Response to the High School Biology in Japan.
Shinki Ishikawa, Hisataka Ohta, Minoru Itoh* (Tokyo University of Science, Japan)

P1-A15 Educational Experiment under the Microgravity Condition in a Parabolic Flight of MU-300.
Seiko Yajima*, Masafumi Watanabe, Takumi Hasegawa, Masahiro Kamata (Graduate School of Tokyo Gakugei University, Japan)

P1-A16 Critical Thinking and Learning Achievement by the Open Inquiry Learning Activities
Charoenkhul Rattanavongsa*, Bunterm Tasanee[1] (khon khan university, Thailand), (Khon Kaen University, Thailand)[1]

P1-A17 A Narrative Inquiry of an Exemplary Science Teacher's Professional Growth
Ching-san Lai*, Hsiu-chi Hsieh[1], Pei-jen Chen (National Taipei University of Education, Taiwan), (Ren Ai Elementary School, Taiwan)[1]

P1-A18 Item Analysis of Test of Using Scientific Evidence for Pre-Service Elementary School Teachers in Taiwan
Chih-Chiang Yang*, Hui-Fang Chan (National Taipei University of Education, Taiwan)

P1-A19 Middle School Students' Knowledge State Analysis about Light
Hyong-Jae Lee*, Ji-Seon Ha, Sang-Tae Park (Kongju National University, Korea)

P1-A20 The Specialization of Mathematics and Science Textbook Approval System in Korea
Eunjin Pyeon*, Jonghyeun Yun (Korea Foundation for the Advancement of Science & Creativity, Korea)

P1-A21 Difficulties Encountered in Understanding Acid-Base Chemistry
Romklao Artdej* (Khon Kaen University, Thailand)

P1-A22 Assessment of Development of Chemistry Epistemic Style of High School Students
Yao Zhi*, Lei Wang (Beijing Normal University, China Mainland)

P1-A23 Screening Gifted Students in Science through Observation in the Classroom
Sung-Soo Jun*, Ho-Kam Kang[1] (Kyungwon University, Korea), (Gyeongin National University of Education, Korea)[1]

P1-A24 Development of Teaching Materials for Underachievers in Middle School Science
Hyang Suk Kim*, Byung Soon Choi (Korea National University of Education, Korea)

Poster Exhibition 1-B — *(p. 99)* — *Main Room*

P1-B1 Developing Web-Based Virtual Geological Field Trip Using Flash Panorama and Exploring its Utilization
Ki-Young Lee* (Kangwon National University, Korea)

P1-B2 The Impacts on Science Learning Using a Microcomputer-Based Laboratories Instruction
Huang-Ming Huang*, Jong-Pyng Chyuan (National Taipei University of Education, Taiwan)

P1-B3 Sixth Graders' Learning of Animal Classification with Internet Resources: Higher Achievers vs Lower Achievers
Ngai-Ying Fiona Ching*, Wing-Mui Winnie So (The Hong Kong Institute of Education, Hong Kong)

P1-B4 The Impact of On-Line Inquiry Learning on Students Competencies in Identifying Scientific Question and Scientific Explanation Ability
Mei-Hsian Chen, Hsiao-Ching She, Kevin Lai* (National Chiao Tung University, Taiwan)

P1-B5 Development of an Eco-Friendly Animation-Based Courseware Using Multi-Media for Primary and Secondary School Students in Environmental Education
Kew-Cheol Shim*, Keum-Hyun So[1], Sung-Hee Yeau[2], Ji-Hyon Kil[3] (Kongju National University, Korea), (Pusan National University of Education, Korea)[1], (Ewha Womans University, Korea)[2], (National Institute of Environmental Research, Korea)[3]

P1-B6 Visualization Materials of Geometrical Object in Junior High School Mathematics: Use of a 3D Dynamic Geometry Software
Mai Miyata*, Katsuhiko Shimizu (Tokyo University of Science, Japan)

P1-B7 Integrating Taiwan Indigenous Culture into Elementary Science Teaching
Huey-Lien Kao*, Chih-Lung Lin, Ching-Yi Chang[1], Wei-Min Hsu, Chi-Liang Chang (National Pingtung University of Education, Taiwan), (Tajen University, Taiwan)[1]

P1-B8 The Effects of S-BEL Program on Middle School Students' Awareness about Scientific Literacy and Attitudes Changes
Ji Seon Ha*, Hyeong Jae Lee, Kee Ju Jeong, Sang Tae Park (Kongju National University, Korea)

Wednesday, October 26, 2011 *Venu: Haeoreumgwan*

P1-B9 Development of Scientific Creativity Behavioral Characteristics Checklist Based on Analysis on Physicists' Behavior in Growth Period
Wonho Shin*, Jongwon Park[1] (Bigeum Middle School, Korea), (Chonnam National University, Korea)[1]

P1-B10 Developing Science Learning Activities Considering Characteristics of Gifted Learner
Je Heung Kim*, Chan-Jong Kim[1], Seung Urn Choi[1] (Bucheon Buk Girls Middle School, Korea), (Seoul National University, Korea)[1]

P1-B11 Improvement of Students' Problem Finding And Hypothesis Generating Ability: Gifted Science Education Program Utilizing Darwin's Theory of Evolution
Bong-Seon Kim*, Soon-Ok Kim, Eun-Joo Kim, Hae-Ae Seo (Pusan National University, Korea)

P1-B12 The Effect of Scaffolding Instruction on Improving Argumentation Skills of the Sixth Grade Students in Socioscientific Contexts
Shu-Sheng Lin*, Yen-Cheng Su (National Chiayi University, Taiwan)

P1-B13 By Construction of Concept Map to Investigate What is the Necessary Literacy of Grade 3 to 12 Students in Nano-Science
Chih-Hsiung Ku*, Yao-Chou Ho, Yi-Ji Tsai (National Dong Hwa University, Taiwan)

P1-B14 Socioscientific Issues as an Instructional Tool for Creativity and Character (CreActer) Education
Jung-eun Yang, Hyunjeong Kim*[,1], Lei Gao[1], Eunjin Kim[1], Hyunju Lee[1] (Banghak Middle School, Korea), (Ewha Womans University, Korea)[1]

P1-B15 Media Influence on Korean Middle School Students' Decision-Making of Nuclear Power Generation Issues
Hyunok Lee*, Eun-hang Lee, Jinhee Kim, Ja-hee Lee (Ewha Womans University, Korea)

P1-B16 Evaluation of the Effect of Competence Indicators on Energy Conservation and Carbon Reduction Camp
Pei-Hsuan Lan, Chih-Chun Hsu, En-Tsun Chou, Hsueh-Chih Chen*, Hak-Ping Tam (National Taiwan Normal University, Taiwan)

P1-B17 Scientific Literacy Reflected within Decision Making: Based on Written Decision Making about Socio-Scientific Issues
SunYoung Ko*, SeungUrn Choi[1] (Shinhyun Middle School, Korea), (Seoul National University, Korea)[1]

P1-B18 Merapi Mountain Eruption and its Potency for Socioscientific Issues Education
Agung Wijaya Subiantoro Chusairi* (Yogyakarta State University, Indonesia)

P1-B19 A Consideration of the Science Class with the Theme of Color of Natural Things as Traditional Culture in Japan
Kazushige Mizobe* (Hyogo University of Teacher Education, Japan)

P1-B20 Challenge to Special Education Program for Gifted and Talented Children in Science Education in Japan -The Exploratory Study
Tateo Hashimoto, Yukari Hashimoto*[,1] (Nagasaki University, Japan), (Fukuyama University, Japan)[1]

Science Demonstration 1-A *(p. 77)* *Main Room*

SD-A1 Electrolysis and Fuel Cell
Woongmook Lim* (Teachers Bonding Over Chemistry (Whasamo), Korea)

SD-A2 Oxidation and Reduction of Copper
YoungChoul Park* (YeoSu High School, Korea)

SD-A3 Molar Volume of a Gas
Eugene Wee* (Teachers Bonding Over Chemistry (Whasamo), Korea)

SD-A4 The Generation of Chlorine, the Reaction
Gyeong hwan Hong* (Teachers Bonding Over Chemistry (Whasamo), Korea)

SD-A5 Identification of Ions by Using Universal Indicator
Moonseok Go* (Teachers Bonding Over Chemistry (Whasamo), Korea)

SD-A6 Hydrogen Gas Formation Experiment
Kyunghwan Mun* (Teachers Bonding Over Chemistry (Whasamo), Korea)

SD-A7 The Principle of Convection
Dok Il Kim* (Incheon Electronic Meister High School, Korea)

SD-A8 How to Make a Color Ice Pack
KyoungHyun Jang*, Dok Il Kim (Incheon Metropolitan City Office of Education, Korea)

SD-A9 The Effect of The Open Inquiry Learning Activities on Problem Solving Ability, and Learning Achievement
Penporn Wangpoomyai*, Tassance Bunterm (Khon Kaen University, Thailand)

SD-A10 Psychic Tricks?
Nelson C. C. Chen*, Angie Y. C. Chen, Young-Shin Park[1], Claudia H. W. Wang[2], Kai C. K. Chang[2], Afra H. F. Kuo[2] (National Science and Technology Museum, Taiwan), (Chosun University, Korea)[1], (National Kaohsiung First University of Science and Technology, Taiwan)[2]

Science Demonstration 1-B *(p. 79)* *Lobby*

SD-B1 To Observe Resonances with a Double Pendulum
Ho Jin Min* (Wolgye Middle School, Korea)

SD-B2 Confirming Stationary Waves through Flames
Hak Tae Kim* (Munjung Girl's High School, Korea)

SD-B3 Simple Hydraulic Equipment made by Ordinary Straw and Plastic Bag
Duk Young Kim* (Unnam Middle School, Korea)

SD-B4 Cotton Combustion by Gas Adiabatic Compression in an Airtight Container
Jin-ho Choi* (Chosun University High School, Korea)

	Wednesday, October 26, 2011		Venu: Haeoreumgwan

15:20-16:20

Invited Workshop 1 *(p. 62)* *Room1*

chair: Ki-Young Lee (Kangwon National University, Korea)

Chemical Education for Creativity: Knowledge, Judgment, and Representation
Hiroki Fujii, Haruo Ogawa[1] (Okayama University, Japan), (Tokyo Gakugei University, Japan)[1]

Invited Workshop 2 *(p. 69)* *Room2*

chair: Yong Jae Joung (Gongju National University of Education, Korea)

Small Intervention: Big Changes? Changing Pre-service Teachers Ideas About forces
Steven Chapman (University of London, UK)

Contributed Workshop 1 *(p. 75)* *Room3*

chair: Chi-Jui Lien (National Taipei University of Education, Taiwan)

Science Education Content Standards for National K-12 Science Curriculum in Korea
Yoon-Su Baek, Sukgoo Loh[1], HyunJu Park[2], Youngmin Kim[3], Jin-soo Jeong[4], Eun Ah Lee*[5], Eunjeong Yoo[6], Dongwook Lee[7], Jongwon Park[8] (Yonsei University, Korea), (Gyeongin Unversity of Education, Korea)[1], (Chosun University, Korea)[2], (Pusan National University, Korea)[3], (Daegu University, Korea)[4], (Seoul National University, Korea)[5], (Shinsa Middle School, Korea)[6], (KOFAC, Korea)[7], (Chonnam National University, Korea)[8]

Contributed Workshop 2 *(p. 75)* *Room4*

chair: Mariko Suzuki (Shiga University, Japan)

Development of Instruction Modules of Molecular Biology Experiment for High School Students using the DNA of Human Oral Cavity Epithelial cells
Jeong-Im Woo (Chungdam High School, Korea)

Contributed Workshop 3 *(p. 76)* *Room5*

Computer-Based Physics Laboratory: Use of Moving Picture System
Kiyoung Kim (Segye Scientific Co., Korea)

16:20-16:40 **Coffee Break** *Lobby*

16:40-18:20

Oral Presentation 1-A *(p. 80)* *Room1*

chair: Yew-Jin Lee (Nanyang Technological University, Singapore)

01-A1 Inquiry-Science in a Straightjacket?: The Interplay of People, Policies, and Place in an East-Asian Developmental State
Yew-Jin Lee* (Nanyang Technological University, Singapore)

01-A2 Development and the Effects of New Measurement Experiments for the Earth Size
Donghyun Chae* (Jeonju National University of Education, Korea)

01-A3 A Study of Constructing Multimedia to Enhance Science Learning for 5th Graders
Ching-san Lai*, Ming-horng Lai[1] (National Taipei University of Education, Taiwan), (Wan-da Elementary School, Taiwan)[1]

01-A4 The Impacts of the Inquiry-Based General Chemistry Laboratory using the Reading frame-based Science Writing Heuristic Approach on College Students' Reflective Thinking
Eun-A Heo*, Jeonghee Nam (Pusan National University, Korea)

01-A5 A Literature Review of the Role of Morality in Teaching and Learning Socio-Scientific Issues
Jisun Park*, Jinwoong Song (Seoul National University, Korea)

Oral Presentation 1-B *(p. 81)* *Room2*

chair: Youngshin Kim (Kyungpook National University, Korea)

01-B1 Analysis of Changes in the Ecological Niche of the Concept of Photosynthesis in 7th Grade through Lessons
Soomin Lim*, Youngshin Kim (Kyungpook National University, Korea)

01-B2 Comparing Scientists' Views of Nature of Science within and across Disciplines, and Levels of Expertise
Praweena Tira*, Valarie Akerson[1], (Institute for the Promotion of Teaching Science and Technology, Thailand), (IUB, USA)[1]

01-B3 Investigation of the Effects of a Visualisation-Based Multimedia Instructional Program on Students' Understanding of Multiple Representations in Electromagnetic Induction Concepts
Hye-Eun Chu*, Jennifer Yeo, Charles Chew[1], Teck Chee Chia (Nanyang Technological University, Singapore), (Academy of Singapore Teacher, Singapore)[1]

01-B4 Using Video Analysis and Cogenerative Dialogues to Expand Science Teaching and Learning Opportunities for Teachers and Students in Urban Schools
Sonya Martin* (Seoul National University, Korea)

01-B5 Validity and Reliability of the Science Motivation Questionnaires with Korean College Students
Kongju Mun*, Sung-Youn Choi, Sung-Won Kim (Ewha Womans University, Korea)

Oral Presentation 1-C *(p. 83)* *Room3*

chair: Yoon Fah Lay (Universiti Malaysia Sabah, Malaysia)

Wednesday, October 26, 2011 *Venu: Haeoreumgwan*

01-C1 An Investigation on the Relationships between Pre-Service Science Teachers' Science Teaching Efficacy Belief and Self-Image as Science Teachers
Yoon Fah Lay*, Chwee Hoon Khoo[1] (Universiti Malaysia Sabah, Malaysia), (Teacher Education Institute-Kent Campus, Malaysia)[1]

01-C2 Elementary Teachers' Conceptions of Science Inquiry Teaching: Cases of South Korea, Singapore and United States
Hye-Gyoung Yoon*, Nam-Hwa Kang[1], Mijung Kim[2] (Chuncheon National University of Education, Korea), (Oregon State University, USA)[1], (University of Victoria, Canada)[2]

01-C3 A PD model of Teachers for Promoting Understanding of Science
Irene Poh-Ai Cheong*, I. J. Kyeleve, Hjh Sallimah Hj Mohd. Salleh, Roslinawati Mohd. Roslan (Universiti Brunei Darussalam, Brunei Darussalam)

01-C4 Development of a Professional Development Model for Improving Science and Mathematics Teaching in Thailand
Pornpun Waitayangkoon* (The Institute for the Promotion of Teaching Science and Technology, Thailand)

01-C5 Explore Chemistry Teacher's Teaching Conceptions System Directing to Teaching Behaviors in the Context of New Curriculum Reform in China
Lei Wang*, Yanning Huang[1] (Beijing Normal University, China Mainland), (Capital Normal University, China Mainland)[1]

Oral Presentation 1-D *(p. 85)* *Room4*

chair: Malinee Chaiyabang (Khon Kaen University, Thailand)

01-D1 Exploring Thai Elementary School Teachers' Understanding of Concepts and Instruction of the Nature of Science
Malinee Chaiyabang*, Kongsak Thathong, Frank Jenkins[1] (Khon Kaen University, Thailand), (University of Alberta, Canada)[1]

01-D2 The History of Science Approach to the Nature of Science: Galileo's Discovery of Moons of Jupiter and the Return of Halley's Comet
Jun-Young Oh*, YoungHo Kim (Hanyang University, Korea)

01-D3 Integrating Webquests into Chemistry Classroom Teaching to Promote Critical Thinking
Qing Zhou*, Huiji Yue[1], Hong Tian, Changying Yin[2] (School of Chemistry and Materials Science of Shaanxi Normal University Xi'an, China Mainland), (School of Physics and Information Technology of Shaanxi Normal University, Xi'an, China Mainland)[1], (Xi' dian Middle School attached to Xidian University Xi'an, China Mainland)[2]

01-D4 Teachers' Conceptions of Teaching and Learning with Internet Resources in Science Inquiry Classrooms
Wing-Mui Winnie So, Ngai-Ying Fiona Ching* (The Hong Kong Institute of Education, Hong Kong)

01-D5 Teaching Biological Processes Using Curriculum Materials based on 3-D Computer Animations
Kyung-A Kwon*, J. Steve Oliver (University of Georgia, USA)

Oral Presentation 1-E *(p. 87)* *Room5*

chair: Hang-Hwa Hong (Western Michigan University, USA)

01-E1 Developing Teaching Materials of Scientific Creativity related to Biological Contents and Pilot Application to Gifted Science Students
Hang-Hwa Hong* (Western Michigan University, USA)

01-E2 Characters of Scientist's Problem Finding and Solving Activities Compared with Those of High School Students
Eugene Kang*, Jina Kim (Pusan National University, Korea)

01-E3 Types of Models and Modeling Behavior of Biology Majors: Implications for Critical Thinking Development
Jocelyn Partosa* (Ateneo de Zamboanga University, The Philippines)

01-E4 The Effect of "Learn to Think" Curriculum on the Scientific Creativity of Secondary School Students
Weiping Hu* (Shaanxi Normal University, China Mainland)

01-E5 Investigating in Students', Teachers' and Parents' Recognition about Contrary Views on Scientific Creativity
Jongwon Park, Kyoungjun Jee*[,1] (Chonnam National University, Korea), (Moonwoo Elementary School, Korea)[1]

Oral Presentation 1-F *(p. 89)* *Room6*

chair: Hongming Ma (Monash University, Australia)

01-F1 Using Native Knowledge to Explore Science Teachers' Understanding of the Nature of Science: A Chinese study
Hongming Ma* (Monash University, Australia)

01-F2 In between Science and People: A Comparative Life Story of Three British Scientists who hoped to change the Society
Jinwoong Song* (Seoul National University, Korea)

01-F3 To Explore the EEG Alpha and Theta Activity During Processing of Biology Concepts
Wen-Chi Chou*, Hsiao-Ching She, Li-Yu Huang (National Chiao Tung University, Taiwan)

01-F4 Expanding Students' Views of Science through Personal Science News Constructing
Chun-Ju(Jerome) Huang* (National Chung Cheng University, Taiwan)

01-F5 Bridging the Gap between Formal and Informal Science Education from Weather Literacy
Yi-Ji Tsai*, Chih-Hsiung Ku (National Dong Hwa University, Taiwan)

19:00-21:00 **EASE Executive Board Meeting** *Room4*

Thursday, October 27, 2011

Venu: Haeoreumgwan

08:30-09:00 **Registration** *Lobby*

09:00-10:00 **Invited Speech 5** *(p. 106)* *Room2*

chair: Tom Thomson (Oregon Department of Education, USA)

'Doing' Science versus 'Being' a Scientist: Examining 10/11-year-old Schoolchildren's Constructions of Science Through the Lens of Identity
Justin Dillon (King's College London, UK)

Invited Speech 6 *(p. 123)* *Room3*

chair: J. Steve Oliver (University of Georgia, USA)

Supporting Students' Integrated Understandings of Big Ideas and Scientific Practices Across Time
Joseph Krajcik (University of Michigan, USA)

10:00-10:20 **Coffee Break** *Lobby*

10:20-11:40 **Oral Presentation 2-A** *(p. 146)* *Room1*

chair: Jinwoong Song (Seoul National University, Korea)

02-A1 Searching for Effective Instruction of Open-Inquiry: The Differences Between Students' and Teachers' Recognition of the Difficulties in Carrying Out Open-Inquiry.
Hyojoon Kim*, Jinwoong Song (Seoul National University, Korea)

02-A2 Exploring Student Metacognition and Science, Technology, Society, and Environment Issues in a Thai Context
Warawun Chantharanuwong*, Kongsak Thatthong, Chokchai Yuenyong, Gregory P. Thomas[1] (Khon Kaen University, Thailand), (University of Alberta, Canada)[1]

02-A3 Exploring Secondary School Students' Views of the Nature of Science in Mainland China
Yingzhi Zhang*, Enshan Liu[1] (Capital Normal University, China Mainland), (Beijing Normal University, China Mainland)[1]

02-A4 Analysis of Types of Questions Embedded in Science Lessons of Japan and the United States
April Daphne Hiwatig*, Manabu Sumida, Hayashi Nakayama[1] (Ehime University, Japan), (University of Miyazaki, Japan)[1]

Oral Presentation 2-B *(p. 147)* *Room2*

chair: Shiho Miyake (Kobe College, Japan)

02-B1 A Case Study of Public Science Communication in the Japanese Museum Symposium
Shiho Miyake* (Kobe College, Japan)

02-B2 A Study on the Science-Gifted Camp at Educational Institutions for the Gifted
Hyun-Chul Jung, Sun Hee Cho*, Mi Young Kim (KAIST Global Institute For Talented Education, Korea)

02-B3 A Science Teacher's Beliefs and Practices of Teaching Nanoscience in an Informal Setting
Pei-Yu Hsieh*, Mao-Jhang Luo[1], Jui-Chou Cheng[1], Paichi Pat Shein, Dong-Hwang Chen[2], Tai-Chu Huang (National Sun Yat-Sen University, Taiwan), (National Kaohsiung Normal University, Taiwan)[1], (National Cheng Kung University, Taiwan)[2]

02-B4 A Study on Development and Application of a Secondary Science Teaching Model Utilizing the Faraday's Idea Developing Process
Seong Oh Jeong*, Youngmin Kim (Pusan National University, Korea)

Oral Presentation 2-C *(p. 148)* *Room3*

chair: J. Steve Oliver (University of Georgia, USA)

02-C1 The Design of Knowledge Transformation System (KTS)
Ji Shen, J. Steve Oliver* (University of Georgia, USA)

02-C2 Generation Green Project in Thailand: Students' Short Films to Promote the Awareness and Action for Climate Change Issues
Suthida Chamrat* (Bureau of Academic Affairs and Educational Standards, Thailand)

02-C3 EEG Brain Activity in Encoding Physics-Related Concepts
Kevin Lai*, Hsiao-Ching She, Sheng-Chang Chen (National Chiao Tung University, Taiwan)

Oral Presentation 2-D *(p. 150)* *Room4*

chair: Hunkoog Jho (Seoul National University, Korea)

02-D1 The Pattern of Risk Assessment and its Role in Undergraduates' Decision-Making across Socio-Scientific Issues
Hunkoog Jho*, Jinwoong Song, Ralph Levinson[1] (Seoul National University, Korea), (Institute of Education, University of London, UK)[1]

02-D2 An Investigation on the Relationships between the Knowledge, Attitudes, and Behaviour Dimensions of Environmental Literacy among Urban and Rural Form 4 Students in Sabah, Malaysia
Yoon Fah Lay*, Chwee Hoon Khoo[1], Sirisena Anuthra[2], Chong Aileen[2] (Universiti Malaysia Sabah, Malaysia), (Teacher Education Institute, Kent Campus, Malaysia)[1], (Teacher, Malaysia)[2]

02-D3 Affective Learning Opportunities in Primary Science Lessons
Kok Siang Tan*, S Nirmala Devi Santhanasamy[1] (National Institute of Education, Singapore), (Xishan Primary School, Singapore)[1]

Thursday, October 27, 2011 *Venu: Haeoreumgwan*

02-D4 Analysis of Korean High School Students' Moral Reasoning Patterns: Using Essays on the Nuclear Power Generation Issue
Jihye Lee*, Sumin Bae, Seungeun Lee (Ewha Womans University, Korea)

Oral Presentation 2-E *(p. 151)* *Room5*

chair: Chee Leong Wong (Nanyang Technological University, Singapore)

02-E1 Can Definitions contribute to Alternative Conceptions?
Chee Leong Wong*, Kueh Chin Yap (Nanyang Technological University, Singapore)

02-E2 Effects of Cooperative Small Group Discussion on Elementary School Students' Argumentation and Attitudes toward Science in Taiwan
Zuway-R Hong*, Huann-shyang Lin, Hsin-Hui Wang, Hsiang-Ting Chen, Kuay-Keng Yang (National Sun Yat-sen University, Taiwan)

02-E3 From Situational Interest to Individual Interest: The Impact of a Classroom Intervention on College Students' Perception of Learning Science
Huann-shyang Lin*, Zuway-R Hong, Ya-Chun Chen, Kuay-Keng Yang (National Sun Yat-sen University, Taiwan)

02-E4 The Relationships among Pre-Service Chemistry Teachers' Attitude-Towards-Chemistry, Chemistry Self-Efficacy, and Chemistry Learning Experiences at Tertiary Level
Yoon Fah Lay*, Chwee Hoon Khoo[1] (Universiti Malaysia Sabah, Malaysia), (Lecturer, Teacher Education Institute-Kent Campus, Malaysia)[1]

Oral Presentation 2-F *(p. 153)* *Room6*

chair: Jocelyn Partosa (Ateneo de Zamboanga University, The Philippines)

02-F1 Metacognition as a Tool in Advancing Reading Comprehension in a Science Class
Jocelyn Partosa* (Ateneo de Zamboanga University, The Philippines)

02-F2 To What Extent are Social Constructivist Perspectives Implemented in Asian Primary Science Education? The Case of Vietnam
Vu Thu Hang Ngo*, Marijn Meijer, Albert Pilot (Utrecht University, The Netherlands)

02-F3 Using Concept Maps as a Mean to Align Junior and Senior High School Science Curricula
Hak-Ping Tam*, Choo-Chin Chen, Yi-Hsiu Yeh, Chun-Yu Tsai (National Taiwan Normal University, Taiwan)

02-F4 Why does Science Inquiry Stumble in the Classroom? A Meta-Analysis of Studies Dealing with Science Inquiry in Korea
Jina Chang*, Jinwoong Song (Seoul National University, Korea)

11:40-11:50 **Coffee Break** *Lobby*

11:60-12:20 **EASE General Assembly** *Main Room*

chair: Youngshin Park (Chosun University, Korea)

12:20-13:20 **Lunch (Lunch box)** *Main Room*

13:20-14:20 **Oral Presentation 3-A** *(p. 154)* *Room1*

chair: Bongwoo Lee (Dankook University, Korea)

03-A1 Unweaving Rainbow: Teaching Science Using Rainbow
Bongwoo Lee*, Heekyong Kim[1] (Dankook University, Korea), (Kangwon National University, Korea)[1]

03-A2 Effect of Nanotechnology Instructions on Senior High School Students
Chow-Chin Lu*, Chia-Chi Sung (National Taipei University of Education, Taiwan)

03-A3 Inquire Learning Effects to Elementary School Students' Nanotechnology Instructions
Yueh-Yun Chen, Chow-Chin Lu*[1], Chia-Chi Sung[2] (New Taipei City Sioushan Elementary School, Taiwan), (National Taipei University of Education, Taiwan)[1], (National Taiwan University, Taiwan)[2]

Oral Presentation 3-B *(p. 155)* *Room2*

chair: Kanchulee Punyain (OBEC, Thailand)

03-B1 Science Project: An Innovation from School to Community (English Integrated Science Approach)
Kanchulee Punyain*, Nason Phonphok[1], Sitthisak Gindawong (Office of the Basic Education Commission, Thailand), (Srinakharinwirot University, Thailand)[1]

03-B2 SoSTI Course: An Elective Science Course for Thai Upper Secondary School Non-Science Students
Chaninan Pruekpramool* (Science Education Center, Srinakharinwirot University and Thailand Center of Excellence in Physics, CHE, Thailand)

03-B3 Let me Hear your Story: Exploring the Role of Everyday Experience of Primary Students to Promote Science Discourse during Peer Discussion
Jiyeon Na*, Jinwoong Song (Seoul National University, Korea)

Oral Presentation 3-C *(p. 157)* *Room3*

chair: Gyoungho Lee (Seoul National University, Korea)

03-C1 Exploring the Origin of a Science Teacher's Dilemma: A Case of Teaching Newton's First Law
Gyoungho Lee* (Seoul National University, Korea)

Thursday, October 27, 2011 *Venu: Haeoreumgwan*

13:20-14:20

03-C2 Preservice Science Teachers' Awareness of Knowledge and Skills for Inquiry Teaching during Their Teaching Practices in Schools
Jirakan Yuenyoung, Chokchai Yuenyong* (KhonKaen University, Thailand)

Oral Presentation 3-D *(p. 157)* *Room4*

chair: Lilia Halim (UKM, Malaysia)

03-D1 Students' Perception Concerning Science Teachers' Pedagogical Content Knowledge
Lilia Halim*, Sharifah Intan Sharina Syed Abdullah, T. Subahan Meerah (UKM, Malaysia)

03-D2 Metacognition that Pupils Realize their Changes in Thought
Mitsuru Nakajo* (Kochi University, Japan)

03-D3 Development of Inquiry-Based Teaching Program via PCK and UbD: A Professional Development for Biology Preservice Teacher
Kamonwan Klaiwong*, Nalena Praphairaksit, Manat Boonprakob, Wanida Tanaprayothsak (Srinakharinwirot University, Thailand)

Oral Presentation 3-E *(p. 159)* *Room5*

chair: Yu-Ling Lu (National Taipei University of Education, Taiwan)

03-E1 A Preliminary Study on the Effectiveness of Integrating the Creative Thinking Teaching Approach with Educational Game Learning for Improving Traditional Science Teaching
Jiun-hung Chen, Chien-Ju Li*, Chi-Jui Lien, Yu-Ling Lu (National Taipei University of Education, Taiwan)

03-E2 Enhancing the Creative Problem Solving Skill by Using the CPS Learning Model for Seventh Grade Students with Different Prior Knowledge Levels
Kanyarat Cojorn*, Numphon Koocharoenpisal, Sunee Haemaprasith, Pramuan Siripankaew[1] (Srinakharinwirot University, Thailand), (Institute for the Promotion of Teaching Science and Technology (IPST), Thailand)[1]

03-E3 An Analysis of Pattern of Creative Scientist's Problem Finding and Hypothesis and Program Development for Improving Secondary School Students' Creativity through its Application: Einstein's Case
Jaekwon Kim*, Youngmin Kim (Pusan National University, Korea)

Oral Presentation 3-F *(p. 160)* *Room6*

chair: Huann-shyang Lin (National Sun Yat-sen University, Taiwan)

03-F1 The Interplay of Teachers' Conceptions of Inquiry, their Curriculum Plans and Teaching Practices
Shu-Fen Lin, Huann-shyang Lin*, Yi-ying Wu (National Sun Yat-sen University, Taiwan)

03-F2 Improving College Students Understanding of Time-Varying Velocity during Elastic Collision Using Microcomputer-Based Laboratory
Jong-pyng Chyuan* (National Taipei University of Education, Taiwan)

03-F3 The Impact of Argument-Based General Chemistry Laboratory Investigations Using the Science Writing Heuristic (SWH) approach on College Students' Use and Embedding of Multimodal Representations in Summary Writing
Jeonghee Nam, Dongwon Lee*, Hyesook Cho, Aeran Choi[1] (Pusan National University, Korea), (Kent State University, USA)[1]

14:20-14:40 **Break**

14:40-15:40

Poster Exhibition 2-A *(p. 172)* *Main Room*

P2-A1 The Study of Exploring Elementary School Students' Scientific Explanation by Using the POE Strategies
Ching-Chi Chen, Chi-Jui Lien[1], Yu-Ling Lu*[1] (New Taipei City Chen-Gong Elementary school, Taiwan), (National Taipei University of Education, Taiwan)[1]

P2-A2 The Effects of Science Writing Program on Middle School Students' Creativity and Science-Related Attitude.
Shin young Hwang*, Young Ran Jeong (Ewha Womans University, Korea)

P2-A3 Analysis of Laboratory Activities in High School Biology Textbooks Used in China and Korea
Seju Kim*, Enshan Liu[1] (Beijing Normal University, China Mainland), (Beijing Normal University, China Mainland)[1]

P2-A4 The Resource Development and Application of Visual-Analogical Learning for Understanding Conceptual Light and Waves for Middle School Students
Do-Wan Kim*, Eugene Kang, Jina Kim (Pusan National University, Korea)

P2-A5 Development of the Task-Based Assessment Tools for Scientific Creativity (TATSC)
Kyounghak Lee*, Jongwon Park, Hwanjea Jung (Chonnam National University, Korea)

P2-A6 Needs for 3D Teaching Materials in High School Biology Teaching
Chieko Uchiyama*, Minoru Itoh, Keishi Kojima (Tokyo University of Science, Japan)

P2-A7 Understanding about the Principle and the Donation of High Science and Technology through Research Activity of the Inventions
Seungwoo Yi*, Hyunsuk Jeoung, Youngmin Kim (Pusan National University, Korea)

P2-A8 A Model for the Teaching of Column Separation Science
Peter Peng Foo Lee*, Yong Chua Teo, Timothy Ter Ming Tan, Kelvin Jin Tai Koh (Nanyang Technological University, Singapore)

P2-A9 Perception and Difficulties of Teachers and Students on the Extra-Class Science Activities Operated at Science Core Schools
Jeehye Hong*, Hun-Gi Hong (Seoul National University, Korea)

Thursday, October 27, 2011 — Venu: Haeoreumgwan

P2-A10 The Application of the Problem-Based Learning Model for Science Unit "Environment" and Analysis of its Effects
Sookyong Park* (Kyungnam University, Korea)

P2-A11 The Transfer of Competent Students' Problem Solving Strategies in Graphs to a Teaching Model in Senior High School Physics
Jang-Jenq Chen, Ming-Jun Su[1], Sung-Tao Lee*,[2] (Toying Senior High School, Taiwan), (Shu-Te University, Taiwan)[1], (National Taichung University of Education, Taiwan)[2]

P2-A12 A Study on Teacher's Awareness of Questioning and Teaching Practices in Elementary Science Class
Min-Jung Cho, Chui Im Choi*,[1] Sang-Ihn Yeo (Gyeongin University of Education, Korea), (Seoul National University, Korea)[1]

P2-A13 Exploration of Energy Unit of Korean Science Textbook from an Viewpoint of 21th Century Scientific Literacy
Kongju Mun, Miyoung Cho, Yoonsook Chung, Jiyoung Mun, Sung-Won Kim* (Ewha Womans University, Korea)

P2-A14 High School Students' Perception and Application of Physics Formulae
Kyung-Hwa Park, Jiyeong Mun, Wanseon Kim, Sung-Won Kim* (Ewha Womans University, Korea)

P2-A15 Explore Girls' Science Self-Efficacy by Astronomy Symposium
Ming-jun Su* (Shu-Te University, Taiwan)

P2-A16 Explore Elementary Teachers' Professional Knowledge of Guiding Science Fair Product by Using Different Instruction Models
Chow-Chin Lu* (National Taipei University of Education, Taiwan)

P2-A17 "Finding N.E.M.O." in the Science Classroom: A Four-Step Approach to Effective Lesson Planning-Implementation
Kok Siang Tan* (National Institute of Education, Singapore)

P2-A18 The Gap between Pre-Service Teachers' Implicit Knowledge and Practical Knowledge on Implementing ARCS Motivating Strategy
Jee-Young Park*, Ji-Eun An, Heui-Baik Kim (Seoul National University, Korea)

P2-A19 A Case Study of an Exemplary Science Teacher's Professional Development
Ching-san Lai*, Pei-shan Lo[1], Pei-jen Chen (National Taipei University of Education, Taiwan), (Fou Shing Elementary School, Taiwan)[1]

P2-A20 A Case Study of Integrated Science Instruction by Pre-Service Science Teacher Applied Science Instructional Models
Yeon-a Son, Seokjun Hong*, Jiyong Kim (Dankook University, Korea)

P2-A21 A Study on the Recognition and Requirements on The Integrative STEM Education
Hyonyong Lee*, Hyeryoung An, Jungchul Nam[1], Youngjae Oh[2], Heejin Oh, Yongki Kim[2], Dongil Sohn[3], Bohyun Seo[4], Youngeun Lee[5], Hyuksoo Kwon[6], Kyunsuk Park (Kyungpook National University, Korea), (Hyunpoong Elementary School, Korea)[1], (Hwadong Elementary School, Korea)[2], (Hosan High School, Korea)[3], (Kyungil Middle School, Korea)[4], (Jinpyung Middle School, Korea)[5], (Gongju National University of Education, Korea)[6]

Poster Exhibition 2-B — *(p. 178)* — *Main Room*

P2-B1 A New Astronomy Education Web Site for Child-Care Support People
Akihiko Tomita* (Wakayama University, Japan)

P2-B2 Development of Professional Competency Indicators for Mathematics Pre-service Teachers in Taiwan Junior High Schools
Chih-Chiang Yang*, Dun-Yao Lin[1] (National Taipei University of Education, Taiwan), (Taipei Municipal Zhongshan Junior High School, Taiwan)[1]

P2-B3 Examining Pre-service Physics Teachers' Conceptualizations of Teaching about Light Properties
Chokchai Yuenyong* (Khon Kaen University, Thailand)

P2-B4 Teacher's Response Change to Students' Incorrect Answers in Earth Science Classroom
Hye Jin Han*, Hye Jun Im, Chan-Jong Kim (Seoul National University, Korea)

P2-B5 Korean Science Teachers' Pedagogical Content Knowledge (PCK) Represented in Teaching Practice at Middle School Classroom
Seonghey Paik, Eun-Jung Bang, Jeong-Ae Won*, Hee-Jung Min, Sang-Hui Lee, Eun-Jung Shin (Korea National University of Education, Korea)

P2-B6 Why We need Better Pedagogical Approach Physics Education in Korea: A Case Study of In-Service Teachers' Difficulties in Electricity
Jung Sook Lee*, Jung Bog Kim[1] (Seoul National University, Korea), (Korea National University of Education, Korea)[1]

P2-B7 The Genesis of Math Affect
Roger Marapo*, Jonny Pornel[1], Naci John Trance[2] (University of St. La Salle, The Philippines), (University of the Philippines in the Visayas, The Philippines)[1], (Western Visayas College of Science and Technology, The Philippines)[2]

P2-B8 Toulmin's Approach to Develop New Teaching Strategies of Argument-Centered Science Learning
Man-Seog Chun*, Young-Shin Park[1] (Korea Science Academy of KAIST, Korea), (Chosun University, Korea)[1]

P2-B9 Exploring Secondary Preservice Earth Science Teachers' Abilities of Developing Inquiry Questions
Jung-Hoon Kim*, Se-Hwan Jeong, Hyoung-Bum Kim[1], Young-Shin Park (Chosun University, Korea), (Korea National University of Education, Korea)[1]

P2-B10 Motivation Factors Among Non-Science Students
Nilda W. Balsicas*, Rosalina M. Makalintal[1] (St. Dominic College of Asia Philippines, The Philippines), (La Consolacion College Manila, The Philippines)[1]

P2-B11 Study about Decision-Making of College Students Who are Enrolled in Liberal Art Class Related to Science
Yoonsook Chung*, Sung-Won Kim (Ewha Womans University, Korea)

Thursday, October 27, 2011 — **Venu: Haeoreumgwan**

14:40-15:40

P2-B12 The Effect of Employing Science Inquiry Question Development Guide: The Case of Biology
Ho-Hyun Lee*, Soo-A Kim, Young-Kyo Jung, Young-Shin Park (Chosun University, Korea)

P2-B13 Exploring Preservice Teachers' Abilities of Developing Scientific Inquiry Questions: The Effect of Using Inquiry Question Guide Questionnaire
Young-eun Jung*, Hee-jin Chun, Ae-jung Kim, Won-ah Kwack, Young-Shin Park (Chosun University, Korea)

P2-B14 The Development and Application of an Analysis Frame of Error Type for High School Students' Observation in Biology Experiments Using Microscopes
Hyun-Jung Jin, Jung-Ho Byeon*, Seung-Hyuk Kwon, Yong-Ju Kwon (Korea National University of Education, Korea)

Science Demonstration 2-A *(p. 143)* *Main Room*

SD2-A1 Atwood's Machine
Jong Deok Chung* (Samhyun Girl's High School, Korea)

SD2-A2 Interesting Electricity
Jongwon Park, Jin-kuk Kim* (Chonnam National University, Korea)

SD2-A3 Fluid Pressure, Surface Tension, Friction
Wonho Shin* (Bideum Middle School, Korea)

SD2-A4 Shoot the Floating Ball in Turbulence with Automatic Bamboo Gun.
Nelson C. C. Chen*, Angie Y. C. Chen, Young-Shin Park[1] (National Science and Technology Museum, Taiwan), (Chosun University, Korea)[1]

SD2-A5 Confucius of a jar, Siphon Toys, Magnetic gun
Youngsik Yoon* (Haeryong High School, Korea)

SD2-A6 Vacuum Experience, Electromagnetic force, Moment of inertia
Min Ju Kim* (Gwangyangbaegun Middle School, Korea)

SD2-A7 Earth's Magnetic Field, Simple Voltmeter
Geukjeong Bang* (Mokpo Jeil Girls High School, Korea)

SD2-A8 Sonic boom, Gravitational Acceleration, Acceleration
Sung Deuk Lee* (Gurye High School, Korea)

Science Demonstration 2-B *(p. 144)* *Lobby*

SD2-B1 Understand the 'Atmosphere phenomenon'
Hyo Yeol Kim* (Kunoe Middle School, Korea)

SD2-B2 How to make Comet
Sinae Sin* (Wando High School, Korea)

SD2-B3 The Change of four Seasons
Miseon Jeong* (Wando Girls Middle School, Korea)

SD2-B4 How to Make Fossils?
Song-Cheol Kim* (Damyang High School, Korea)

SD2-B5 Secondary School Students to Understand the Conceptual Change of Lunar Phases
Mi Hyun Lee* (Ilsin Middle School, Korea)

SD2-B6 Effect of Atmospheric Pressure
Hyung-rae Son* (Wando Middle School, Korea)

15:40-16:40

Invited Workshop 3 *(p. 133)* *Room1*

chair: Bongwoo Lee (Dankook University, Korea)

New Research Methods in Science and Education and Further Implications
Chia-Ju Liu (National Kaohsiung Normal University, Taiwan)

Contributed d Workshop 4 *(p. 141)* *Room2*

chair: Hisashi Otsuji (Ibaraki University, Japan)

Demonstration on Cause for Seasons
Donghyun Chae (Jeonju National University of Education, Korea)

Contributed d Workshop 5 *(p. 141)* *Room3*

chair: Gyoungho Lee (Seoul National University, Korea)

A Tiny Tool to Demonstrate Energy Conversion Between Light and Electricity
Masafumi Watanabe, Masahiro Kamata (Tokyo Gakugei University, Japan)

Contributed d Workshop 6 *(p. 141)* *Room4*

chair: Hyunju Lee (Ewaha Womans University, Korea)

The Meaning and the Scope of the STEAM Education
Jean S. Chung (Korea Foundation for the Advancement of Science & Creativity, Korea)

Contributed d Workshop 7 *(p. 141)* *Computer Lab*

Thursday, October 27, 2011 — Venu: Haeoreumgwan

chair: Prumuan Siripankaew (The Institute for the Promotion of Teaching Science and Technology, Thailand)

Understanding Science Using Math and Excel Computer Program
Seung-Urn Choe (Seoul National University, Korea)

16:40-17:00 Coffee Break — *Lobby*

17:00-18:40 Oral Presentation 4-A *(p. 161)* *Room1*

chair: Jui-lin Chen (National Taipei University of Education, Taiwan)

04-A1 The Habitat Creation on Campus to Improve Elementary School Students' Ecological Learning of Insects
Jui-lin Chen*, Chow-Chin Lu (National Taipei University of Education, Taiwan)

04-A2 Analysis and Development of Expert Conception in Junior High School Nanotechnology Curriculum in Taiwan
Hui-chen Chang*, Chow-chin Lu, Chia-Chi Sung[1] (National Taipei University of Education, Taiwan), (National Taiwan University, Taiwan)[1]

04-A3 Exploring Model Co-Construction and Group Norms by the Patterns of Social Interaction
Eunhee Kang*, Shinyoung Lee, Heui-Baik Kim (Seoul National University, Korea)

04-A4 The Effect of the Open Inquiry Learning Activity
Ganya Ratchahoon*, Tassanee Bunterm, Jintanaporn Wattanatorn, Supaporn Muchimapura (Khon Kean University, Thailand)

04-A5 The Effect of the Reading Framework in Implementation of the Science Writing Heuristic (SWH) Approach in Secondary Science Classroom
Mirye Koh*, Jeonghee Nam, Jong-yoon Park[1], Mijung Kim[1] (Pusan National University, Korea), (Ehwa Womans University, Korea)[1]

Oral Presentation 4-B *(p. 162)* *Room2*

chair: Hong-Wen Cheng (National Taipei University of Education, Taiwan)

04-B1 Using a 3-D Actual Model -the "Sun Altazimuth"- to Support Student Understanding of Concepts of the Sun-Earth Relations
Hong-Wen Cheng*, Han-Ching Wang (National Taipei University of Education, Taiwan)

04-B2 Extracting Statements Describing the Nature of Scientific Observation(SDNSO) and Teaching it to High School Students
Sangsoo Kim*, Jongwon Park[1] (Korea High School, Korea), (Chonnam National University, Korea)[1]

04-B3 Using KWL and CUD to Enhance and Assess Students' Learning and Encourage Students' Questioning on Force and Motion in Grade 10
Siranan Bamrungkul*, Pramuan Siripunkaew[1] (Kalasin Pitayasan School, Thailand), (The Institute for the Promotion of Teaching Science and Technology, Thailand)[1]

04-B4 The Impacts of Writing in Argument-Based Inquiry on Science Learning
Hyeongjeong Kil*, Jeonghee Nam, Aeran Choi[1] (Pusan National University, Korea), (Kent State University, USA)[1]

04-B5 Investigation and Improvement of Students' Reading Comprehension Performances in Science Pictures
Fu-Pei Hsieh, Sung-Tao Lee*,[1] (Kuang-Hua Primary School, Taiwan), (National Taichung University of Education, Taiwan)[1]

Oral Presentation 4-C *(p. 164)* *Room3*

chair: Angie Y. C. Chen (National Science and Technology Museum, Taiwan)

04-C1 Promoting Pre-Docents' Understandings and Practices in the Context of Informal Setting
Angie Y. C. Chen*, Nelson C. C. Chen, Young-Shin Park[1] (National Science and Technology Museum, Taiwan), (Chosun University, Korea)[1]

04-C2 The Learning Experiences of Participants of Science Cafes in Japan
Miku Yoshida* (The University of Tokyo, Graduate School of Interdisciplinary Information Studies, Master Course, Japan)

04-C3 An Examination of the Notion of Scaffolding in an Informal Science Learning Context
Eun Ji Park*, Jieun Park, Seul Kee Park, Eugene Jeong, Chan-Jong Kim (Seoul National University, Korea)

04-C4 The Influence of Teaching Strategies to the Learning Interest of Junior High Students in Informal Nanoscience Camp
Jui-Chou Cheng*, Tai-Chu Huang[1], Jeng-Fung Hung[2], Dong-Hwang Chen[3], Terry Yuan-Fang Chen[3], Jen-Fin Lin[3] (National Science and Technology Museum, Taiwan), (National Sun Yat-sen University, Taiwan)[1], (National Kaohsiung Normal University, Taiwan)[2], (National Cheng Kung University, Taiwan)[3]

04-C5 Relationship Between Thinking Styles and Self-Regulated Learning Ability and Scientific Inquiry Ability of Korean Science Gifted Students
Jiae Lee*, Sookyong Park[1], Youngmin Kim (Pusan National University, Korea), (Kyungnam University, Korea)[1]

Oral Presentation 4-D *(p. 166)* *Room4*

chair: Hye-Eun Chu (Nanyang Technological University, Singapore)

04-D1 Students' Understanding in Different Contexts of fundamental Optics in Singapore and Korea
Hye-Eun Chu*, David Treagust[1] (Nanyang Technological University, Singapore), (Curtin University, Australia)[1]

04-D2 A New Model for Math Affect
Jonny Pornel*, Roger Marapo[1], Naci John Trance[2] (University of the Philippines Open University, Philippines), (University of St. La Salle, Philippines)[1], (Western Visayas College of Science and Technology, Philippines)[2]

04-D3 Primary School Students' Scientific Literacy and Reading Ability: The Study in Thailand
Punika Praputtakun* (Srinakharinwirot University, Thailand)

04-D4 Analyzing the Special Science Elementary School Project for Gifted Children in the Philippines
Joel Faustino*, Manabu Sumida (Ehime University, Japan)

Thursday, October 27, 2011 — Venu: Haeoreumgwan

17:00-18:40

04-D5 Redefining the Underlying Structure of the ROSE Instrument and its Application to Understand Chinese Students' Affective Domain of Science Learning
Yau-yuen Yeung*, May Hung May Cheng[1] (HKIED, Hong Kong), (Oxford University, UK)[1]

Oral Presentation 4-E — *(p. 168)* — *Room5*

chair: Hyunju Lee (Ewha Womans University, Korea)

04-E1 Pre-Service Science Teachers' Decision-Making Trajectory on Socioscientific Issues
Hyunju Lee*, Hyunsook Chang[1] (Ewha Womans University, Korea), (Kuksabong Middle School, Korea)[1]

04-E2 How Beliefs Regarding the Nature of Science Interact with Worldview Presuppositions held by Korean In-Service Science Teachers and Biologists
Hang-Hwa Hong*, William Cobern (Western Michigan University, USA)

04-E3 Exploring Scientific Literacy of Undergraduate Engineering in Thailand Contexts
Rungrat Thummathong*, Kongsak Thatthong (Khon Kaen University, Thailand)

04-E4 Beginning Teachers' Struggling Toward their Profession of Scientific Inquiry: Theory into Practice
Young-Shin Park* (Chosun University, Korea)

04-E5 A Framework for Local Ecotourism in Maragondon, Cavite, Philippines: Implications to Curriculum Development
Nilda Balsicas*, Alejandro Magnaye (St. Dominic College of Asia, The Philippines)

Oral Presentation 4-F — *(p. 169)* — *Room6*

chair: Hisashi Otsuji (Ibaraki University, Japan)

04-F1 Approaching Cultural Background in Science Instruction: An Example of Japan Influenced by Mahayana Buddhism
Yuta Tasaki, Hisashi Otsuji* (Ibaraki University, Japan)

04-F2 The Study of Korean View of Nature
Yumi Lee*, Yeon-a Son (Dankook University, Korea)

04-F3 Students' Visual Representation of Mathematics
Naci John Trance*, Roger Marapo[1], Jonny Pornel[2] (UP Open University/Western Visayas College of Science and Technology, The Philippines), (University of St. La Salle, The Philippines)[1], (University of the Philippines in the Visayas, The Philippines)[2]

04-F4 Fidelity of Implementation: Building on What We Have Done in Science Education Research
Yew-Jin Lee* (Nanyang Technological University, Singapore)

04-F5 Case study Applied Thomas Young's Hypothesis Formulation Process through Analogy about the Interference Phenomenon of Light
Wonsook Kim*, Youngmin Kim (Pusan National University, Korea)

18:40-19:00 **Moving to Conference Banquet Venue**

19:00-21:00 **Conference Banquet** — *Gwangju Ramada Plaza Hotel*

Friday, October 28, 2011 — Venu: Haeoreumgwan

08:30-09:00 **Registration** — *Lobby*

09:00-10:00

Oral Presentation 5-A — *(p. 202)* — *Room1*

chair: Tsun-hui Shih (National Taipei University of Education, Taiwan)

05-A1 A Study of the Learning Outcome on the Teaching of Biodiversity in the Zoo for Fifth Grade Students
Tsun-hui Shih*, Ching-san Lai (National Taipei University of Education, Taiwan)

05-A2 Study on the Chemistry Epistemic Style of High School Students
Lei Wang*, Yao Zhi, Hong Xiao (Beijing Normal University Chemistry College, China Mainland)

05-A3 Inculcation of Action Research Culture among Science and Technology University's Lecturers
T. Subahan Mohd Meerah*, Lilia Halim (National University of Malaysia, Malaysia)

Oral Presentation 5-B — *(p. 203)* — *Room2*

chair: Hye-Gyoung Yoon (Chuncheon National University of Education, Korea)

05-B1 A Case of Pre-service Teachers' Efforts to Improve their Science Inquiry Teaching: Focusing on the Comments of Experts and Reflective Activities
Hye-Gyoung Yoon*, Yong Jae Joung[1], Mijung Kim[2], Young-Shin Park[3], Byung Sug Kim[4] (Chuncheon National University of Education, Korea), (Gongju National University of Education, Korea)[1], (University of Victoria, Canada)[2], (Chosun University, Korea)[3], (Roosevelt University, USA)[4]

Friday, October 28, 2011 *Venu: Haeoreumgwan*

05-B2 A Preliminary Case Study of a One-year Teaching Mentoring: Program and Professional Growth in Elementary Science Teaching
Shue-Tai Cheng*, Tzu-Yun Chung[1], Chi-Jui Lien (National Taipei University of Education Department of Science Education, Taiwan), (New Taipei City Chang Ping Elementary School, Taiwan)[1]

05-B3 Beliefs of Excellent Science Teachers
Myrna Quinto* (Far Eastern University, The Philippines)

Oral Presentation 5-C *(p. 204)* *Room3*

chair: Yau-yuen Yeung (HKIED, Hong Kong)

05-C1 School-Based Support for Immersing Digital Technology into the Inquiry-Based Project Learning of Science in a Primary School
Yau-yuen Yeung*, Zhihong Wan (HKIED, Hong Kong)

05-C2 A Preliminary Case Study on Science Teachers' Difficulties of Becoming an Educational Game Developer
Wei-Ming Chen*, Yi-Wen Wang, Jian-Da Chen, Yu-Min Chen, Pei-Chi Sung, Yu-Ling Lu (National Taipei University of Education, Taiwan)

05-C3 Fostering Pre-service STEM Teachers' Technological Pedagogical Content Knowledge: A Lesson Learned from Case-based Learning Approach
Niwat Srisawasdi* (Khon Kaen University, Thailand)

Oral Presentation 5-D *(p. 205)* *Room4*

chair: Mashita Abdullah (Nan Hwa Secondary School, Malaysia)

05-D1 Small Scale Approach for Teaching and Learning Chemistry in Malaysia
Mashita Abdullah*, Norita Mohamed[1], Zurida Hj Ismail[1] (Nan Hwa Secondary School, Malaysia), (Universiti Sains Malaysia, Malaysia)[1]

05-D2 Exploring Reasoning Process in Collaborative Modeling by Small Group Interaction Type
Shinyoung Lee*, Eunhee Kang, Heui-Baik Kim (Seoul National University, Korea)

05-D3 Improvement of Students' Problem Finding and Hypothesis Generating Ability: Gifted Science Education Program Utilizing Mendel's Law
Soon-Ok Kim*, Bong-Seon Kim, Soo-Young Kim, Hae-Ae Seo (Pusan National University, Korea)

Oral Presentation 5-E *(p. 206)* *Room5*

chair: Nilda Balsicas (St. Dominic College of Asias, The Philippines)

05-E1 Motivation Factors Among Non-Science Students
Nilda Balsicas*, Rosalina Makalintal (St. Dominic College of Asias, The Philippines)

05-E2 University Students' Understanding of Wave-Particle Duality
Yong Wook Cheong*, Jinwoong Song (Seoul National University, Korea)

05-E3 The Effect of Reading Science Popular Books on the Nature of Science of College Students
Hao-Chang Lo* (National Taichung University of Education, Taiwan)

Oral Presentation 5-F *(p. 207)* *Room6*

chair: Seungho Maeng (Seoul National University of Education, Korea)

05-F1 For the Learning Progressions in Asian Science Education Research: Analytic and Comparative Review of Asian, European, and American Studies on Conceptual Trajectories in Science Learning
Seungho Maeng* (Seoul National University of Education, Korea)

05-F2 Comparison Between the Thinking Styles of Students in a Science School and a Normal Secondary School
Bob Chui Seng Yong* (Universiti Brunei Darussalam, Brunei Darussalam)

05-F3 Toward an Academic Discipline of Science Education with Chinese Features
Bangping Ding* (Capital Normal University, China Mainland)

10:00-10:20 **Coffee Break** *Lobby*

10:20-11:00

Invited Workshop 4 *(p. 184)* *Room1*

chair: Nelson Chen (National Science and Technology Museum, Taiwan)

Practical Ways for Teaching and Evaluating Scientific Creativity
Jongwon Park (Chonnam National University, Korea)

Regional Special Session *(p. 198)* *Room2*

chair: Jinwoong Song(Seoul National University, Korea)

Comparative Survey of Science Culture Indicators on Regional Level in East Asia
Jinwoong Song (Seoul Nat'l Univ., Korea), Masakata Ogawa (Tokyo Univ. of Science, Japan),
Chiaju Liu (National Kaohsiung Normal Univ., Taiwan), Enshan Liu (Beijing Normal Univ., China Mainland),
May Hung May Cheng (Oxford Univ., UK), Young-Shin Park (Chosun Univ., Korea)

Friday, October 28, 2011			Venu: Haeoreumgwan

10:20-11:00 **Contributed d Workshop 8** *(p. 199)* *Room3*

chair: Jeonghee Nam (Pusan National University, Korea)

Using Microbial Fuel Cells for the Integrated Teaching of the Natural Sciences
Timothy T. M. Tan, Peter P. F. Lee, Yew Jin Lee (National Institute of Education, Singapore)

Contributed d Workshop 9 *(p. 199)* *Room4*

chair: Yew-Jin Lee (Nanyang Technological University, Singapore)

Propose of New Experiments about Motion of Gas Molecules through Analysis of Experimental Errors
Dae Hong Jeong, Jongho Baek (Seoul National University, Korea)

Contributed d Workshop 10 *(p. 199)* *Room5*

chair: Sungmin Im (Daegu University, Korea)

Measuring Changes in Balance of Oxygen and Carbon Dioxide in the Air: Combustion Experiment Using Gas Detector Tubes
Moonjung Han* (Sookmyung Girl's High School, Korea)

11:00-12:00 **Poster Exhibition 3-A** *(p. 217)* *Main Room*

P3-A1 Learning Math From Travelling: Math Weekend Camp for Indigenous Children
Ru-Fen Yao* (National Chia-Yi University, Taiwan)

P3-A2 Cases of the Approaches from Science Communication to Science Education in Japan
Mariko Suzuki[1], Akiko Tsuzuki[1,2]*, Takashi Kusumi[3], Itsuo Hatono[4], Mikihito Tanaka[5], Kei Kano[3], Eri Mizumachi[3], Tamaki Motoki[3], Katsuya Takanashi[3, 6] (Shiga University, Japan)[1], (Marine Learning Center, Japan)[2], (Kyoto University, Japan)[3], (Kobe University, Japan)[4], (Waseda University, Japan)[5], (Japan Science and Technology Agency, Japan)[6]

P3-A3 A Study of 4th Graders' Informal Science Learning at Taipei Zoo
Ching-san Lai* (National Taipei University of Education, Taiwan)

P3-A4 Teachers' Perceptions and Interactions Concerning a Multi-Disciplinary Integrated Approach to Science Teaching
Jungyong Ahn*, Jinwoong Song (Seoul National University, Korea)

P3-A5 What Young Children Know about Bats: A Summative Evaluation of Museum Educational Program by Visitor Study
Hui-fen Kao*, Jung-hua Yeh, Mei-chun Lydia Wen[1] (National Museum of Natural Science, Taiwan), (National Changhua University of Education, Taiwan)[1]

P3-A6 The Survey of Elementary School Teachers Toward Climate Change Issues in Interactive Multimedia System - National Taiwan Science Education Center Science Activities as Example
Chien-kuo Ku*, Qiu-Lan Chen, Gia-Yan Shen (Taipei Municipal University of Education, Taiwan)

P3-A7 The Change in Inquiry Abilities of Physically Challenged Students by Science Class Based on POE Approach in Informal Education Environment
Sang-yong Park*, Hong-jeong Kim, Sung-Jae Pak, Sungmin Im (Daegu University, Korea)

P3-A8 Perceptions of Teachers and the Effectiveness of PBL programs Using the Science Museum.
Juneuy Hong* (Seowon University, Korea)

P3-A9 Exploring Factors Influencing Docents' Theory and Practice
Se-Hwan Jeong*, Jung-Hwa Lee, Young-Shin Park (Chosun University, Korea)

P3-A10 How Evolution was Taught in Japanese Secondary Schools Before World War II
Kazumasa Takahashi*, Tetsuo Isozaki (Hiroshima University, Japan)

P3-A11 The Scientific Imagination Appeared in Research Processes Korean Scientists
Jiyeong Mun*, Kongju Mun, Sung-won Kim (Ewha Womans Univesity, Korea)

P3-A12 A Comparative Study of Middle School Students' Images and Perceptions of Scientists, Technicians and Engineers
Hyunyoung Kim*, Youngmin Kim (Pusan National University, Korea)

P3-A13 Pre-Service Science Teachers' Conceptions of the Nature of Science
Jin Choi*, Jae-Sook Lee, Hae-Ae Seo (Pusan National University, Korea)

P3-A14 The Effectiveness of Using ABIM (Argument-Based Inquiry Model) for Scientific Literacy in the Classroom
Jongheon Kim*, Man-Seog Chun[1], Young-Shin Park[2] (Daejeon Science High School, Korea), (Korea Science Academy of KAIST, Korea)[1], (Chosun University, Korea)[2]

P3-A15 Analysis of the Correlation between Classification Ability Quotient and Cortisol-Hormonal Change in Middle School Students
Ye June Bea, Gi Yong Choi*, So Young Kim, Yong Ju Kwon (Korea National University of Education, Korea)

P3-A16 Effects of Concept Map Strategy on Global Warming and Climate Change Course
Hsueh-Chih Chen*, En-Tsun Chou, Chih-Chun Hsu, Yao-tin Sung, Hsin-Tsun Huang (National Taiwan Normal University, Taiwan)

Poster Exhibition 3-B *(p. 222)* *Main Room*

P3-B1 The Teacher's Perception about the Nature of Science Involved in Science Curriculum
Seulae Ku*, Heeyoung Cha (Korea National University of Education, Korea)

P3-B2 Students' and Teachers' Recognition of Illustration in Physics / Textbooks Based on the Revised National Curriculum in 2009 and Advancing Physics of UK: Focusing on Information and Communication Unit
Ju-Ock Seo* (Pusan National University, Korea)

P3-B3 Microorganisms Living Inside Hermetia Illucens's Intestine as a Solution of Reducing Organic Waste
Jongbaek Sung, Jaeah Chung, Jaikoo Lee, Je-Nyeon Kim* (Gyeonggi Science High School for the Gifted, Korea)

P3-B4 A Case Study on Instructional Design Process for Integrated Science Lesson by Secondary Science Teachers: Focused on the Consulting of 5-Step's Instructional Design for Integrated Science Lesson
Eun Ju Lee*, Yeon-a Son (Dankook University, Korea)

P3-B5 The Understanding and Learning Survey of Elementary School Students toward Climate Change Related Facilities
Chien-Kuo Ku*, Mei-Hua Shi, Gia-Yan Shen (Taipei Municipal University of Education, Taiwan)

P3-B6 The Effects of English Partial Immersion Science Classes on Middle School Students' Science Achievement
Sang Woo Lee*, Jeonghee Nam[1] (Busan International Middle School, Korea), (Pusan National University, Korea)[1]

P3-B7 A Study On The Features Of Guduljang Used For Korean Heating System (Ondol)
Su-Bin Sin, Hyun-A Choi[1], Song-Cheol Kim*[,2] (Korea Advanced Institute of Science and Technology(KAIST), Korea), (Chonnam National University, Korea)[1], (Damyang High School, Korea)[2]

P3-B8 Influence on Cognitive Level Development through Student-Student Interaction in the Variable-Controlling Activities
Sang Kwon Lee, Hui Mun* (Chonnam National University, Korea)

P3-B9 Laboratory Safety Signs and Symbols for Science Experiments
HyunJu Park, Juran Shin*[,1] (Chosun University, Korea), (Chosun University Girl's High School, Korea)[1]

P3-B10 Effect of Atmospheric Pressure
Hyung-rae Son* (Wando Middle School, Korea)

P3-B11 Exploring the Influence of Online Metacognitive Scaffolding on Science Inquiry
Wen-Xin Zhang*, Ying-Shao Hsu, Fu-Tai Chuang, Yu-Ting Ho (National Taiwan Normal University, Taiwan)

P3-B12 Elementary and Middle School Science Textbooks Presentation of Energy Conservation and Carbon Reduction in Taiwan
Yao-Ting Sung, Hsin-Tsun Huang* (National Taiwan Normal University, Taiwan)

P3-B13 Upper Ocean Responses to Typhoon Abby in the Northwestern Pacific Using a Three-Dimensional Primitive Equation Numerical Model
Chul-hoon Hong*, Akira Masuda[1], Jong-Hwan Yoon[1] (Pukyong National University, Korea), (Kyushu University, Japan)[1]

P3-B14 Science and Mathematics Major Program (SMMP) in Upper-Secondary Schools in Japan: A Critical Analysis of the Status Quo
Masakata Ogawa* (Tokyo University of Science, Japan)

P3-B15 The Direction of the Teacher's College and the Identity of Chemistry Education Examined by Analyzing Students's Paths in Life and College Plans
Sungwoo Bae*, Jongseok Park (Kyungpook National University, Korea)

P3-B16 Representation of 'Origin of Universe' in the New High School Science Textbooks, 'Blended Science' in Korea
Minna Kim*, Sangwoon Kwon, Gyoungho Lee (Seoul National University, Korea)

P3-B17 Analysing the Gap between Intended and Implemented Physics Laboratory Activities
Thongloon Vilaythong*, Sune Pettersson[1], Oleg Popov[1] (National University of Laos, Laos), (Umea University, Sweden)[1]

Science Demonstration 3-A *(p. 200)* *Main Room*

SD3-A1 Observing an Electric Field and Lightening with Static Electricity
Hyung-do Park* (Hanam Middle School, Korea)

SD3-A2 Making a Electrostatic Motor
Hyeon Cheol Yu* (Gwangju Electronic Technical High School, Korea)

SD3-A3 Condenser (Microphones Made of Aluminum Foil)
Euntai Wi* (Wol-gok Middle School, Korea)

SD3-A4 Sound Filters by Using Condenser or Coil & Speaker Disassembly
Jin Ho Lee* (GwangJu Girl's High School, Korea)

SD3-A5 Mirror Reflection
Jihoon Kim* (Gwangju Science High School, Korea)

SD3-A6 Interesting Reflection
Jongwon Park, Hwoe-gwan Yang*[,1] (Chonnam National University), (Gwangju Science High School, Korea)1

SD3-A7 Pinhole Camera
HanSu Lee* (CheomDan Middle School, Korea)

SD3-A8 How to Show Rising Carbon Dioxide Bubble Dissolved in a Long Tube of Water
Fujio Hiramatsu* (Attached Elementary School of Tsukuba University, Japan)

Science Demonstration 3-B *(p. 201)* *Lobby*

SD3-B1 Several Demonstrations about Total Internal Reflection
Kwangsik Kim* (Chonnam National University, Korea)

SD3-B2 Optical Communication
Seung-Hee Choi* (Gwangju Science High School, Korea)

SD3-B3 Infrared Remote Control
Sang Mi Kang* (Gwangju Computer Science High School, Korea)

SD3-B4 Synthesis and Degradation of Light
Dong Sik Kim* (Unnam Middle School, Korea)

Friday, October 28, 2011 — Venu: Haeoreumgwan

12:00-13:00 **Lunch** — *Solmaru (Cafeteria)*

13:00-14:20

Oral Presentation 6-A — *(p. 208)* — *Room1*

chair: Sau Kheng Au (Ministry of Education, Singapore)

06-A1 Teachers' Inquiry Practices and Beliefs about Implementing Inquiry-Based Laboratory Experiments
Sau Kheng Au* (Ministry of Education, Singapore)

06-A2 The Effect of Science Writing Heuristic on Concept Formation of Lights in Mirrors/ Lenses and Scientific Attitudes
Min-Ah Jeong*, Sunggi Kwon[1], Su-young Lee[2] (Dalsan Elementary School, Korea), (Daegu National University of Education, Korea)[1], (Sungbuk Elementary School, Korea)[2]

06-A3 Understanding Middle School Students' Biological Taxonomy Processes through Small-Group Argumentation
KyungHyun Lee*, Jane Jiyoung Lee, Heui-Baik Kim (Seoul National University, Korea)

Oral Presentation 6-B — *(p. 209)* — *Room2*

chair: Sungmin Im (Daegu University, Korea)

06-B1 Using Cogenerative Dialogues to Explore the Experiences of Korean English Language Learners in the Science Classroom in the US
Sungmin Im*, Sonya Martin[1] (Daegu University, Korea), (Seoul National University, Korea)[1]

06-B2 Analysis and Development of Expert Conception in Junior High School Nanotechnology Curriculum in Taiwan
Hui-chen Chang*, Chow-chin Lu, Chia-Chi Sung (National Taipei University of Education, Taiwan)

06-B3 The Effect of Learning Cycle Model on Conceptual Understanding of Sound for the Students with Intellectual Disability
Hong-jeong Kim*, Sungmin Im (Daegu University, Korea)

06-B4 The Effectiveness of Constructivist Approach-Based Experiments in Teaching Selected Physics Concepts
Lorelei Tabago* (Isabela State University, The Philippines)

Oral Presentation 6-C — *(p. 211)* — *Room3*

chair: Supawadee Tonwongkaew (Khon Kaen University, Thailand)

06-C1 Enhancing Teachers' Knowledge of Science and Mathematics Teaching for Improving Students' Analytical Thinking
Supawadee Tonwongkaew* (Khon Kaen University, Thailand)

06-C2 Influence of Teaching Option and Teaching Experience on Science Teachers' Pedagogical Content Knowledge of Environmental Education
Sharifah Intan Sharina Syed Abdullah*, Lilia Halim (National University of Malaysia, Malaysia)

06-C3 Analysis Chemistry Teacher's Conception of Teaching with Inquiry
Yan-Ning Huang*, Lei Wang[1] (Capital Normal University, China Mainland), (Beijing Normal University, China Mainland)[1]

06-C4 Design and Use Two-Tier Test Fitting for Rasch Model to Investigate Grade 10-11 Students' Understanding of Photosynthesis
Cheng Liu, Enshan Liu* (Beijing Normal University, China Mainland)

Oral Presentation 6-D — *(p. 212)* — *Room4*

chair: Seyoung Hwang (Seoul National University, Korea)

06-D1 A Review of Research on Teacher Professionalism and Identity in Environmental Education
Seyoung Hwang*, Inyoung Hong, Eunjeong Seo, Rena Lee (Seoul National University, Korea)

06-D2 Metacognitive Orientation of Physics Classroom in Thai Contexts
Jirutthitikan Pimvichai* (Khon Kaen University, Thailand)

06-D3 Factors Causing Science Learning Fatigue in Science Museums and Schools
Minchul Kim*, Jinwoong Song (Seoul National University, Korea)

06-D4 Development of Educational Programs for Reinforcement of Science and Technology Ethics Literacy and its Application on Students Majoring Science and Engineering
Kyunghee Choi, Sungsoo Song, Hyang-yon Rhee, Jiyoung Jang*, Sehyun Kim (Ewha Womans University, Korea)

Oral Presentation 6-E — *(p. 214)* — *Room5*

chair: William Palmer (Curtin University, Australia)

06-E1 Jacob Abbott (1803-1879): Lighting the Way for Youth
William Palmer* (Curtin University, Australia)

06-E2 The Organisation of Science (Rika) Education in Japanese Elementary Schools
Tetsuo Isozaki* (Hiroshima University, Japan)

06-E3 HPS/NOS in the Research of Science Education in Korea: Based on the Analysis of the 'Journal of the Korean Association for Science Education'
Yong Jae Joung*, Jinwoong Song[1] (Gongju National University of Education, Korea) (Seoul National University, Korea)[1]

06-E4 Refining Lakatosian Research Program
Kyoung-Eun Yang* (Korea National University of Education, Korea)

Friday, October 28, 2011 — Venu: Haeoreumgwan

Oral Presentation 6-F (p. 215) Room6

chair: Zuway-R Hong (National Sun Yat-sen University, Taiwan)

06-F1 Effects of an Integrated Science and Societal Implication on Promoting Adolescent's Positive Thinking and Emotional
Zuway-R Hong*, Huann-shyang Lin, Hsin-Hui Wang, Hsiang-Ting Chen, Yu-Min Chung, Ya-Chao Wu (National Sun Yat-sen University, Taiwan)

06-F2 I Do Not Want to be a Physics Teacher Any More: Some Pre-service Teachers' Decision After Wandering in College
Kwang-Hee Jo* (Chosun University, Korea)

06-F3 Exploring and Comparing Australian and Korean Students' Perceptions of Scientists and Engineers through Draw-a-Scientist and Draw-an-Engineer Tests
Bernardo Leon de la Barra, Youngmin Kim*[1], Jaeyoung Han[2] (University of Tasmania, Australia), (Pusan National University, Korea)[1], (Chungbuk National University, Korea)[2]

06-F4 Construction of Competence Indicators of Energy and Climate Change
Hsueh-Chin Chen*, Pei-Hsuan Lan, Chih-Chun Hsu, Hong-Tung Chou, Yao-Ting Sung (National Taiwan Normal University, Taiwan)

14:20-14:30 **Break**

14:30-15:00 **Closing Ceremony** — *Main Room*

chair: Hae-Ae Seo (Pusan National University, Korea)

Best Presentation Awards : Sung-Won Kim (Ewha Womans University, Korea)
Closing Remarks : Youngmin Kim (Pusan National University, Korea)

15:00- **Educational Visiting** — *Main Room*

Elementary school
High school
National Gwangju Museum
Gwangju Municipal Folklore Museum

Saturday, October 29, 2011

09:00- **Cultural Visiting**

Nag-An-Eup-Seong Folk Village

- Plenary Session
- Date: Wednesday, October 26, 2011
- Time: 09:40 ~ 10:40
- Room: Main Room
- Chair: Masakata Ogawa (Tokyo University of Science, Japan)

WHY IS AN UNDERSTANDING OF MULTIPLE REPRESENTATIONS SO IMPORTANT IN LEARNING SCIENCE?

David Treagust
Curtin University, Perth, Australia

Abstract

Multiple representations of science concepts such as text, diagrams, analogies, models, mathematical relationships and computer simulations are primarily concerned with helping learners understand the science concepts under investigation. Based on the theoretical framework of Ainsworth, different representations can contain complementary information or support complementary cognitive processes; help learners develop a better understanding of a conceptual domain by using one representation to constrain the interpretations of a second representation; and lead to a deeper understanding of concepts that may include promoting an abstraction, encouraging generalisation, and understanding the relation between representations. Without considering science concepts from the vantage point of several different representations, a full understanding of science is not possible. In this presentation, I describe a range of examples at the secondary school and university level where teachers and students used various effective multiple representations in science teaching and learning and illustrate their effectiveness.

Introduction

In recent years, many science educators have argued that effective engagement in scientific discourse involves flexible use of multiple representations using texts, diagrams, equations, graphs, and charts (Kozma, 2003) and that students need to be able to understand and link different scientific representations to develop a deeper understanding of science concepts (Prain & Waldrip, 2006; Schnotz & Bannert, 2003). While researchers have tried to implement teaching strategies with multiple representations such as texts, diagrams, equations, and graphs to help students better learn science, students seem to find using various representations difficult. The research described in this paper attempts to consider why students have difficulty using a variety of representations and also to show that using a variety of representations can provide a deeper understanding of concepts.

In addition to representations using texts, diagrams, equations, graphs, and charts, chemistry education researchers, Gilbert and Treagust (2009) have classified the multiple representation used in chemistry, referred to as levels, as (1) macroscopic representations that describe the phenotype of organisms and the bulk properties of tangible and visible phenomena in the everyday experiences of learners when observing changes in the properties of matter, such as colour changes, pH of aqueous solutions, and the formation of gases and precipitates in chemical reactions; (2) submicroscopic (or molecular) representations that provide explanations at the genotype of the organism at the genetic level and for matter at the particulate level as being composed of atoms, molecules and ions; and (3) symbolic representations that involve the use of letters, symbols, formula and equations, as well as drawings, diagrams, models and computer animations to symbolise matter.

Whilst biology can be represented by macro, micro/submicro or symbolic levels as in the representational triplet used for understanding in chemical education, the organisation of biological knowledge is different from that in chemistry. Biology is unique in that four levels of representation need to be considered for fully understanding biological phenomena: (1) the macro level where biological structures are visible to the naked eye; (2) the cellular level which is invisible to the naked human eye but visible under a light microscope or the subcellular structures visible under an electron microscope; (3) the molecular level involving DNA or proteins, for example, that can only be identified using analytical tools such as electrophoresis, chromatography, the centrifuge and others; and (4) the symbolic level that provides explanations of phenomena represented by chemical equations and numerical calculations or inheritance patterns through manipulation of symbols. Biological knowledge is hierarchically organized from atoms, through molecules, macromolecules, organelles, cells, tissues, organs, organ systems, organisms, populations, community, ecosystems, to the biosphere. Some latest biology textbooks use multiple representations in several ways to enhance the teaching and learning, for example, by using multilevel perspective to show macro and micro views of complex biological structures, process figures to illustrate complex processes in series of small steps, and colour consistency to organise and clarify concepts.

In physics, phenomena are usually represented at the (1) submicro level as for example when understanding gas laws, (2) at the macro level, for example, when referring to movement of bodies or observable light reflecting from mirrors and (3) at the symbolic level involving equations and graphing relationships. The symbolic representations at their simplest form are equations or graphs of idealised phenomena such a movement of a body across a surface without any friction. However, representations taking into account everything that affects the phenomena such as surface and rolling friction include much more elaborate and complex representations.

How can the Use of Multiple Representations in Teaching and Learning aid Conceptual Understanding?

One attempt to bring research about multiple representations in chemistry under one cover was the edited volume by Gilbert and Treagust (2009). In this volume, chapters were written by our colleagues working on a wide range of research programs that examined how multiple representations were used by teachers and students to enhance learning and also to show the difficulties that arise in both using the different representations and when different multiple representations were not used. Different chapters referred to a range of teaching approaches in chemistry that include the roles of structure-property relationships, visualisation, diagrams, practical work, historical materials, and computer simulations/animations. The challenges in each of these teaching approaches are when and how to introduce the 'representational triplet' so as to avoid the alternative conceptions that are expressed by students. The consequent goal is to devise a scheme of curriculum development and implementation that will ensure that a more rational teaching approach is universally adopted in schools. In summary, macro representations enable the empirical properties of scientific phenomena to be depicted, submicro representations enable those properties to be qualitatively explained, whilst symbolic representations enable the production of quantitative explanations to be produced. Taken together, these three representations play key roles in understanding the nature of chemical entities and their reactions. The various chapters in this book illustrate the importance of using multiple representations and how an appropriate use can result in enhancing conceptual understanding.

In a second volume, Treagust and Tsui (in preparation) have bought together the works of the world's experienced biology educators and biology education researchers from 11 countries across major areas of biological science with a common theme of making pedagogical uses of multiple representations for improving biological education. Of more relevance to school biological education is the notion that multiple representations can be used to address the perennial critique of the deficit in the interconnectedness of knowledge in school biology curricula and shortfalls in the systemic transfer of knowledge across multiple levels of biological organization (e.g., Schonborn & Anderson, 2009). It is also in keeping with systems biology, the latest development of biological science, that aims to identify the systems-level understanding of life phenomena as well as with the increasingly powerful information and communications technology (ICT) that is now ubiquitously available in many schools and homes for learning biology. In this volume, chapter authors illustrate how the use of multiple representations in biology teaching and research enable a better understanding of genetics, biotechnological methods, complex process diagrams, development of representational competence, cell division, climate change, photosynthesis, cellular respiration. In addition, multiple representations are illustrated in experts' views of the knowledge structure of biology and teachers' professional development.

No such volume yet exists that brings together how multiple representations are used in physics education though the literature contains many examples that examine multiple representations in physics under different titles such as *Model Based Learning and Instruction in Science* (Clement & Rea-Ramirez, 2008). A continuing theme in physics education is how representations from everyday life contexts are essential for student understanding of physics and their conceptual development (Chu, Treagust, & Chandrasegaran, 2008). Research shows that the connection between students' earlier life experience and the physics being taught is considered necessary for students' meaning making (Enghag, Gustafsson, & Jonsson, 2007). These statements are illustrative of the need to make cognitive links between the visible entities in physics and their representations which in physics are often in the form of equations of ideal relationships and the related diagrams. Although the connections are important, this learning is not easy to be achieved.

Theoretical Position

One of the reasons for students' difficulties lies in the lack of students' understanding of the form of a representation and in the way in which the representation relates to the science concepts (Ainsworth, 2008). It follows that only after students have built such understanding and have adequate prior knowledge, can they effectively select and use appropriate forms of representations to learn science. Similarly, Cook, Carter and Wiebe (2008) argue that students' limited understanding in related science topics inhibits their ability to interpret graphs or diagrams, and Seufert (2003) asserts that when teachers use multiple representations in their lessons, these need to be carefully planned depending on students' prior knowledge.

Consequently, to effectively teach using multiple representations, it is necessary to explicitly present students with different forms of representations about science concepts that can be inter-related and interpreted based on their existing knowledge. For example, in learning optics, it is necessary for students to be able to represent their conceptual understanding by descriptions, drawings, graphs and equations. A related issue is how representational knowledge can be most effectively assessed. For example, with respect to diagram use, students may be asked to describe a set of diagrams first and explain the concepts using them (Cook et al., 2008; Schonborn & Anderson, 2009) or to use a diagram to represent their understanding of relationships between variables. The first mode of assessment focuses on interpretation and the second is designed to measure students' ability to create different representations to illustrate their learning. In addition, Ehrlen (2009) argues that when students are asked to express their ideas with more than one representation such as with a drawing or words, teachers can have a clearer appreciation of the extent of students' understanding and then are able to guide students' conceptual development to extend their knowledge.

As noted by Harrison and Treagust (2000), in lessons on secondary school organic chemistry, when different models were used to help explain chemical phenomena some students were able to explain coherently with the use of the different models and others were not. An explanation for why some students were able to use different models and others were not was not part of that research program, but the observations indicated that the reasons went beyond a lack of knowledge and was more related to a lack of understanding of the role of one or more models in relation to the chemical compound under investigation. This situation is like that described by Ainsworth (2008) whose research primarily involves computers and multimedia but multiple representational learning environments are ubiquitous and do exist when there is no technology in the classroom. Consequently, her theoretical framework about the functions of multiple representations is used to understand the phenomenon observed in some of the studies reported in this paper.

The first function of multiple representations is to contain complementary information or support complementary cognitive processes. Examples of this function are when different representations such as tables or graphs or text provide equivalent information; for some learners one mode of representation is more easily assimilated than the other but the different representations complement each other. The implication is that when teaching classes, teachers should present students with different representations that express equivalent information because each makes different aspects of the situation more prominent. According to Ainsworth (1999 pp.137) "where learners are given the opportunity to use multiple external representations, they may be able to compensate for any weaknesses associated with one particular strategy by switching to the other". There are rarely situations where a single representation, such as tabulated data, is effective for all tasks.

The second function of multiple representations is that they can help learners develop a better understanding of a conceptual domain by using one representation to constrain their interpretations of a second representation. For example, learners may be presented with a familiar analogy to support their interpretation of a physical phenomenon of which they are less familiar and which is more abstract.

The third function of multiple representations is that they can lead to a deeper understanding of concepts that may include promoting an abstraction, encouraging generalisation, and a clearer understanding of the relationship between representations. For example, domain knowledge may be extended when learners know how to interpret a velocity time graph to know whether or not a body is accelerating and can subsequently extend their knowledge to present the data in tables and acceleration-time graphs.

Instructional Diagrams in Chemistry

Diagrams including chemical diagrams are representations in one or more of a multitude of forms such as an iconic or schematic representation, or graphs and diagrams (Novick, 2006). Scientific diagrams are generally labelled, often drawn to a scale, providing an accurate representation. A significant characteristic of chemical diagrams is in the visual impact of both the macroscopic and sub-microscopic levels that can enhance the development of students' mental models. A chemical diagram can have one or more of a multitude of purposes, namely for explanation, description, instruction, to provide a mental picture or to provide multiple representations. A teaching approach with multiple representations provides learners with the opportunity to synthesise their own mental models.

The value of a diagram in making the link with an abstract concept depends on it being consistent with the learners' needs and being pitched at the learners' level of understanding. Diagrams can have more than just illustrative purposes, expanding the purpose of diagrams to model construction and reasoning (Gobert & Clement, 1999). In this way, chemical diagrams serve as significant teaching tools, which depend on the students' understanding of the diagram and their prior knowledge.

While the characteristics and purpose of diagrams are important, the way the diagram is used in the instruction is equally important. Flow charts, Venn diagrams, Vee-diagrams and concept maps are examples of diagrams in which students diagrammatically represent their understanding. These diagrams are pedagogically powerful because students have to actively construct the representation of their understanding and strategies for using these active diagrams are well documented. By contrast, diagrams of laboratory equipment are passive diagrams, presenting information to students. These traditional diagrams are consistent with transmission-style pedagogy when it is assumed that no specific teaching strategy is needed to ensure student understanding.

In a study by Chittleborough and Treagust (2008), chemical diagrams were intentionally introduced into online pre-laboratory exercises in an introductory university course to improve the teaching of chemistry based on the assumption that students would be better prepared for the laboratory activities through using and interpreting chemical diagrams of the chemical equipment used in the experiments. The desired outcome was for students to be better prepared for laboratory sessions and improve their ability to understand experiments. The online pre-laboratory exercises provided immediate feedback to the students on their response and provided them with an opportunity to redo the exercise if their response was incorrect. The students performed experiments with common lab equipment that was portrayed in the diagrams.

Students' responses to the interview questions revealed limitations in several skills that are advantageous to develop when learning chemistry. Firstly, several students were unable to represent or talk about the sub-microscopic level which influenced their ability to interpret diagrams at the sub-microscopic level. Students with limited chemical background commonly interpreted the chemical diagrams at a macroscopic level seeing only the laboratory equipment. Secondly, there was a lack of attendance to the details of the diagram even though throughout the interviews students were challenged to interpret diagrams more critically. Thirdly, there was a lack of evidence of using chemical terminology accurately. The students' verbal responses that used everyday language and chemical phrases carelessly contrasted with the precise and limited nature of chemical vocabulary with which many of these students were not familiar. Using Ainsworth's analysis, this is an example where lack of knowledge of one representation at the sub-microscopic level constrained their understanding at the macro level.

The study highlighted the difficulties experienced by students with little or no chemical background knowledge who have not had the opportunity to develop these necessary skills and demonstrate their use of different representations. Throughout the interviews, additional information on the diagrams proved to be beneficial to students' understanding. The complementary diagrams of the macroscopic, sub-microscopic and symbolic levels of representation, as was done for example with the diagram about an equilibrium reaction, showed the connection with experimental experience. Using Ainsworth's analysis, these complementary diagrams reinforced the idea of connecting both the macroscopic and the symbolic diagrams that aided understanding of the sub-microscopic level.

The results of this study could be used to inform pedagogical content knowledge about teaching with chemical diagrams. Students did not always interpret diagrams correctly, even though they did answer online pre-laboratory questions on the diagrams, suggesting that there is a need for strategies that would promote active interaction with diagrams enabling a deeper understanding between the real word of chemical laboratory and the representation in diagram form. Consistent with a constructivist approach, these suggested strategies require the students to demonstrate their understanding of multiple representations and receive feedback. In this way, the diagram becomes an active tool rather than a passive tool for learning. However, despite ensuring that these were active diagrams rather than passive diagrams, the students' use of diagrams did not guarantee better understanding of chemical concepts.

Assessment Using Multiple Representations

In a three-year study, we have examined students' use of multiple representations within the first year physics curriculum. Of particular interest was to investigate how well students can use multiple representations to explain physics phenomena when these had been presented in class. All 36 lectures were observed and analyzed to ensure that we documented the range and extent of multiple representations used in the teaching. Subsequently, pencil and paper questionnaires were developed on two topics—thermal physics and optics—where the questions were designed to relate to students' everyday life experiences. To assist in students' understanding of the structure of the questionnaire, an example was provided showing how to answer the questions using four different representations - word descriptions, diagrams, equations, and graphs. To increase the accuracy of scoring, four researchers initially evaluated eight students' responses independently and agreed upon the criteria. Then, one person marked all students' work.

Following students' completion of the questionnaires, in order to gain insight into students' perspectives on their use of multiple representations, 75 students were interviewed at the end of the semester with their individual questionnaire answers used as a prompt for interviews. The interviewer asked students to elaborate on their answers, their use of multiple representations for learning, and their difficulty in using them. Each interview session lasted for 20-35 minutes. All interview sessions were recorded and ten interview sessions with more articulate students were fully transcribed.

Despite the explicit prompt to use various representations in the questionnaire, students adopted only about two representations to solve the problems (means of 1.62 for pre-test and 2.37 for post-test). Nevertheless, after the instruction that provided a wide range of representations, the difference between pretest and posttest scores of students' responses di show statistically significant difference for all representations except formula ($p<0.01$). The effect size ranged from .57 and .67 (medium effect) to .96, 1.05 and 1.17 (large effect).

Based on the interview data, Ainsworth's (2006) analytical framework was used to evaluate how students make sense of the physics concepts using the different multiple representations. While some students were confident in explaining physics concepts in words, the unfamiliarity of using diagrams to solve physics problems made them very uncomfortable. According to Ainsworth's framework, the diagrammatic properties of the representation constrained the development of these students' understanding. However, the students' inability to visualize the concepts in diagrams led him to realize that his understanding was incomplete and prompted him to seek better understanding of the concepts.

Concluding Comments

The research reported in this paper has illustrated the importance of using multiple representations such as text, diagrams, analogies, teaching models, mathematical relationships and computer simulations in science teaching and learning. Further, examples of this research have shown how students' use of and understanding of the role of multiple representations is necessary to develop a holistic conceptualisation of science topics. These different representations have been shown to help learners understand the science concept in terms of the underlying features of the concept at a deeper level and help make connections between concepts that were otherwise not easily comprehended. As noted in the research on students' use of active diagrams, even with the clear intention of improving students learning, developing connections between the diagrams of the macroscopic level (equipment), the sub-microscopic level (molecular) and the symbolic level (equations) were not always apparent to students and when taught in an overt manner using multiple representations in physics, the majority of students were not able to use more that two of four representations effectively. Research continues to examine these issues.

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- Invited Speech 1
- Date: Wednesday, October 26, 2011
- Time: 11:00 ~ 12:00
- Room: #2 (1F)
- Chair: Sung-Tao Lee (National Taichung University of Education, Taiwan)

BUILDING A COMMUNITY OF PRACTICE FOR FACILITATING INFORMAL SCIENTIFIC INQUIRY ACTIVITIES IN KOREA

Shinho Jang
Seoul National University of Education, Korea

Introduction

Recently, nation-wide multiple efforts in Korea have put on improving the quality of science education that would take critical roles to improve students' scientific literacy particularly in inquiry skills and creative reasoning (Ministry of Education, Science & Technology, 2010). However, there have been concerns that proper systems and environments are not yet well grounded for carrying out the national reform efforts (Park, 2011). These include lack of formal and informal support system, including schools and other institutional corporations (Cohen & Hill, 1998), for helping students' inquiry practices through providing a good ground for their learning for inquiry and creative reasoning.

Under the recent national reform context in Korea, there have been various governmental attempts to build a community of practice to support and facilitate students' informal inquiry activities nation-wide. For example, these attempts involve building environments by inviting various research institutes to provide high quality inquiry activities. The invitation took a wide range of OUTREACH form, which links educational institutions with other fields like business companies, research institutes, etc.

The paper examines how a community of practice is built in response to the national reform efforts to establish the systems of students' informal inquiry practice, while trying to make the reform idea feasible. And this paper also explores how different people (actors) situate themselves in the process of building the community, shaping their own believes and taking their idiosyncratic roles. By comparing and contrasting the different actors' expectations, believes and actions, this paper ultimately discuss what kinds of crucial factors and elements need to be considered for building a meaningful community of practice for facilitating informal scientific inquiry.

The Analytical Framework

The framework explicates the nature of community of practice as a social context for facilitating informal inquiry. It also provides a description of different elements to affect social practice in the community, which involves social fields acting as useful lenses to better understand interactions and mechanisms occurring in the community of practice for informal inquiry practice in Korea.

A Community of Practice

A community of practice involves much more that the technical knowledge or skill associated with undertaking some work we intend. Members are involved in a set of relationships over time (Lave and Wenger, 1991). The community develops around things that matter to people, including students, teachers, parents and others (Wenger, 1998).

For science education, a community of practice functions to generate and appropriate a shared repertoire of ideas and commitments for facilitating and supporting students' inquiry and scientific learning. The community also needs to develop various resources such as tools, documents, routines, vocabulary and symbols that in some way carry the accumulated knowledge of the community. In other words, it involves practice: ways of doing and approaching things that are shared to some significant extent among members.

Interactions involved and the ability to undertake larger or more complex activities and projects through cooperation, bind people together and help to facilitate relationship and trust. A community of practice can be seen as self-organizing systems and have many of the benefits and characteristics of different attempts to achieve the ultimate goals for students' learning and inquiry in the end.

Social Fields: Grounds for Implementing a Reform

Members of a community are informally bound by what they do and what they want to do (particularly in shaping students' practice). Along with a community of practice, this paper also employs the concept of social "field" as an analytic framework. The concept of a field, suggested by Ladwig (1994), is extensively used to better understand how the various actors[1] in the community position themselves in making social relationships and connections to other actors to achieve the ultimate goal of promoting students' learning practice in nation. This framework is also useful to delineate the multiple dialogues between different actors in various fields in enacting the new reform efforts for facilitating students informal inquiry works.

Ladwig (1994) argues that in order to think of social actions within the arena of educational field, the actions of players can be described within a field. The field can be a place that human actions take place "relationally." He argues:

> *A field is seen as a micro-social structure made up of the objective relations among its players. These relations can be taken to be objective to the extent that they are inter-subjectively recognized; that is, they are taken as objective but the players within the field and acted upon in the everyday struggles of the field. (Ladwig, 1994, p. 344)*

Ladwig also defines a field as "a relational network configured by the multiple interactions between the actors". (Bourdieu, 1973; Ladwig, 1994) On the one hand, the relations can be harmonious and collaborative through sharing intimacy among its players. On the other hand, however, the social field is also likely to have contradictions and competitions between the various perspectives and environments encountered to the actors.

In the different social fields along with various individual beliefs, it is noteworthy that there are conflicts, debates and power relationships between different actors and various fields such the field of education, of government, and of educational reform efforts. As Ladwig (1994) points out, there is possibly autonomy in the field of educational policy in relation to the field of education. Thus, it is possible to assume that some players in the field of educational policy have more power than others in the other field. Interactions among the various fields tend to reveal hierarchical relationships.

This paper attempts to make use of the concept of social field to analyze individual actor's action and position based on their individual understanding of what the practice functions within the system. Through the individual actor's social relations and interactions to others, as Ladwig argues, individual group of actors also reveals idiosyncratic dispositions to determine their social actions and shape their own inclinations toward a particular educational reform.

Research Questions

The purposes of this study are to better understand how a community of practice is built in response to the national reform efforts to settle down students' informal inquiry practice. And this paper also explores how different people (actors) situate themselves in the process of building the community, shaping their own believes and taking their idiosyncratic roles.

While laying out the different social fields along with various individual beliefs, this paper also examines what kinds of possible conflicts and power relationships between different actors and various fields such as the fields of education, government, and educational reform efforts. By comparing and contrasting the different actors' expectations, believes and actions, I ultimately discuss what kinds of crucial factors and elements need to be considered for building a meaningful community of practice for facilitating informal scientific inquiry.

Methods

Informants

The data presented in this paper come from the experiences and thoughts of a group of people who participated in a national project, so called "Donation for Education in 2010," that build the system to promote students' informal inquiry activities in Korea . They were governmental officers in Department of Education, Science and Technology, teachers, staffs and researchers in various institutes in Outreach context.

They took part in the project either by carrying out the reform policy through providing programs and fa-

1) "Actors" is here used in this paper, following Ladwig(1994). Actors can be also understood as "players" or "participants" in slightly different manner. In this paper, I prefer to use "participants" instead.

cilities, or by participating in the provided programs to enhance students/teachers informal inquiry activities. All of them volunteered to participate in this study exploring their ideas, expectations and experiences.

Data Collection and Analysis

For the study, we collected data on various participants in this national project. The participants had a range of backgrounds and expectations for students' inquiry practice. The data include interviews focusing on their experiences, expectations and expected roles in which they were engaged during the project. Another data include videotaped activities, reports, autobiographies, portfolios, and activity worksheets, reflection and collected artifacts such as student work that students and teachers engaged in during various inquiry programs supported by various institutes participating in Donation for Education.

Data analysis for this study focused on answering a research question of how a community of practice is built in response to the national reform efforts and of how different people (actors) situate themselves in the process of building the community, shaping their own believes and taking their idiosyncratic roles. This made it possible for us not only to trace their various goals and expectations, but also to clarify which characteristics of their engagement influence which aspects of building a community of practice in terms of social field where different actors shape their roles.

Findings

This section describes the stories of various participants' engagement in the community of practice to promote students' informal inquiry environment. The participants' particular ways to participate in and contribute to building a community are described. Each participant demonstrated that their ways to respond to the new reform efforts are very various and idiosyncratic. Their ways to respond to the new reform for inquiry enactment are closely associated with their values, expectations, beliefs, and goals they develop as active participants in the social field.

Ways to Participate in Building a Community of Practice

To effectively and appropriately react to the new reform efforts for students' informal inquiry activities, various participants showed their best ways to participate in building a community of practice. They wanted to promote the inquiry environment, which can be considered as a social field, so that different participants actively join to nurture the meaningful field for students' inquiry learning. However, all of them showed that they had the strong needs to have that kind of the community, but with different reasons.

When the participants showed their responses to the new inquiry reform, all of them made their strong agreement to build a community of practice, which can make it more effective to carry out the goal of facilitating students' inquiry learning system nation-wide. That is, all of them had the same need to have the community, but with slightly different reasons and goals.

A deputy director in Ministry of Education, Science & Technology in Korea told his goals and needs to join Donation for Education movement and have a community of practice.

> *I never felt the needs to have Donation for Education for our society. However, I now believe the new reform is important and crucial at this point. ⋯ but the current problem is ⋯ we have not formed Donation culture for our students and society. Participating in that kind of meaningful works promotes students' inquiry and creativity. It is very useful for everybody.*

Regarding new reform works, other official added his thoughts.

> *For me, this kind of reform attempt is very new. ⋯ I did not know much about this kind of work. However, I think that this attempt would give all of them a lot of pleasure.*

Researchers, who worked for institutes as an Outreach cooperate, told his need to have the community as inquiry promoter environment.

> *When I first faced with this kind of community building efforts, I thought this would be absolutely fun.*

Teachers told their goals and needs to have this kind of support system. The teachers participated in some of the programs the Outreach institutes offered to promote the deep understanding of scientific concepts and inquiry based learning environment.

> *This was very good. ⋯ it is very useful for us, teachers, to better understand the science. Because we cannot have this kind of quality inquiry works in schools, this kind of experience provided by Outreach program would be very unique (Choi, teacher)*

> *For me, this kind of help would be great both for teachers and students. Having this kind of support, we can teach better science in schools. This work should be expanded more and more (Lee, teacher)*

As we can see above, all of the participants showed the strong need and aspiration for the community of practice to make it happen. However, they also revealed their different reasons and purposes to have the community.

> *The goals are important to remember. But I know it is not that simple to implement well. This is not a short game. People need to keep going for the goals ⋯ the government role is to pursue the goals and lead the people to go (A, Deputy director)*

> *It is so vague to make it happen⋯ I know it is important. It is a national effort, but it takes a lot of energy to make things work⋯ (B, Government officer)*

> *We need to return what we have to the public in return. It is time to change⋯ We are voluntary⋯ but our chair of our institute is the key to enact⋯ we kind of tend to rely on his decision (Director of G research institute)*

> *We definitely welcome these kinds of works. We (teachers) tend to just follow what we got from the Ministry of Education. It would be great for us to have this kind of support⋯ having authentic inquiry experiences⋯ (C, teacher)*

As we can find from above interviews, most participants are pretty satisfied with what they engaged in. They all were eager to have the opportunity to merge things together for inquiry reform. Particularly they emphasized building this form of community so that they can make things work in collaborative manner.

Interestingly, they all seemed to be aware of their different roles and responsibility of what to do. The government officers thought that they need to push things so that the new policy can be established throughout the future education system. On the other hand, other participants like researchers and teachers tended to think that they could follow what the government guide. But they also thought that it could happen only when they feel those attempts and changes make sense to them. At that point, the new inquiry policy by shaping Donation for Education project seemed to be OK for them.

Various Values, Beliefs, and Eexpectations

Various participants in the project to responded to the national reform accordingly. However, each participant showed different values, beliefs and goals for promoting students' inquiry learning environment through the community of practice. It somewhat reflected their different positions in social field.

A deputy director told his values and expectations of the community of practice for supporting inquiry environment.

> *We believe this new policy would work ⋯ more and more for the future⋯ but it also has a problem that most people do not know about this. They are not used to this kind of new thing. But this is good to do together. This is our task as a government (a deputy director)*

From the interview above, we can see how he positioned himself in the new reform move. He seemed to take a role to pursue the national reform, which implies him as a policy maker viewpoint in social field.

Dr. Chang, a director of G research institute, told his beliefs about managing the new community.

> *Trying this new attempt is something we need to do. While we work together through the community, we can make meaningful contributions to the public and society.*

Differently from Dr. Chang, however, other researchers at the same institute revealed the very different ideas. They came to provide service regardless of their own decision. Under this condition, their views were very different.

> *For me, this is a BIG burden. I do not like this way of doing things. I got involved because I had to do it. … Through up-down power, I had no choice to do it… I would like to quit! (Cho, researcher)*
>
> *I spent 3 or 4 hours for 1 hour class. But our main job is not to teach children outside of our institute. Instead we must do our work, which is doing research for journal paper (Yoon, researcher)*

They ended up saying that they prefer not to get involved in this new reform work.

Another participant, school teacher, exhibited different perspectives. He emphasized the usefulness of having this kind of support that provides better system for helping his own teaching practice.

> *I agree that this would be a big help for teachers as well as students. But I worry that this kind of system might be short-term or temporary… if we want to have a good support, then it needs to be high-quality. Other than that, it might not be that useful. For example, teachers can learn things to apply what they get through their active participation to their classroom practice. (Park, teacher)*

The teacher was saying that the quality matters. According to him, the quality of the program for students and teachers and the quality of the community of practice would be essential to achieve the important goals. It seems the teacher, as a consumer, cares much about having guaranteed support in terms not only of support duration but also of contents.

As we can see the findings above, different participants show different values and expectations about the community of practice that they were pursuing.

Discussion

In this study, different ways to respond to the new reform were described in the context of the community of practice. From the stories of various participants' engagement in the community of practice, this paper laid out ways to promote students' informal inquiry environment. The participants' particular ways to participate in and contribute to building a community are described. Each participant demonstrated that their ways to respond to the new reform efforts are very various and idiosyncratic.

It turned out that participants' various ways to respond to the new reform for inquiry enactment are closely associated with their values, expectations, beliefs, and goals they develop as active participants in the social field. When the participants showed their particular responses to the new inquiry reform, all of them made their strong agreement to build a community of practice, which can make it more effective to carry out the goal of facilitating students' inquiry.

Although all of them retained the same need to have the community, they showed quite different reasons and goals. For example, the government officers thought that they need to push things so that the new policy can be established throughout the future education system. On the other hand, other participants like researchers and teachers tended to think that they could follow what the government guide. But they also thought that it could happen only when they feel those attempts and changes make sense to them.

These findings give us a sense of their ways to participating in social field. We can understand how each participant contributes to shaping and constructing a social field in different role. Policy makers join to the social field in ways in which they prepare and carry out the new reform. Researchers in cooperate institutes shape the field by engaging themselves in running the particular inquiry programs as donors or providers. School teachers also joined the social field to respond to the new reform by participating in the programs offered by other participants in various contexts.

This paper also described what kinds of possible conflicts appeared in different participants due to their revealing their various goals, expectations, and values. The policy makers in Ministry of Education, Science & Technology seemed to take a role to pursue the national reform, which implies him as a policy maker viewpoint in social field. They showed their beliefs that the new reform policy must keep going but they concerned it is not easy to push the public to follow the national guide.

Researchers were very anxious about the new reform, though. Although they participate in Donation for Education project, they did not like working for that. They even did not have less interest in participating in the community of practice that would accelerate their practice for new reform. On the other hand, school teachers were very positive to the reform policy only when they had support and help from other participants. They emphasized the quality of the community of practice which is essential to achieve the important goals. It seems the teacher, as a consumer, cares much about having guaranteed support in terms not only of support duration but also of contents. Otherwise, they did not seem to continue acting and working for the new reform.

By comparing and contrasting the different participants' expectations, believes and actions, I ultimately discuss what kinds of crucial factors and elements need to be considered for building a meaningful community of practice for facilitating informal scientific inquiry.

** Further discussions will be made when I make a presentation at the conference.

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- Invited Speech 2
- Date: Wednesday, October 26, 2011
- Time: 11:00 ~ 12:00
- Room: #3 (1F)
- Chair: Sunyoung Kim (Chosun University, Korea)

A REVIEW ON PRIMARY SCHOOL SCIENCE TEXTBOOK IN CHINA: FEATURES AND PERCEPTIONS OF STUDENTS AND TEACHERS

Lingbiao Gao
South China Normal University, China Mainland

China has undergone a new phase of national curriculum reform since 2001. The original primary subject "Nature" was changed to "Science". The aims and the focuses of the course, the content, and the teaching philosophy have changed greatly compared to the former course "Nature". Meanwhile, the Chinese government changed the so-called "one-textbook" policy and allows a variety of textbooks to be published and used in China. Currently, there are 8 sets of primary science textbooks published by different publishers and used by students all over the country. How are the qualities of these new textbooks? What are the features of the new textbooks compared to their former counterparts? How do the students and teachers perceive these textbooks? Answers to these questions will give an overall picture of Chinese school science textbooks. This will be significant for textbooks and curriculum development both in and out of China. In 2007, the Ministry of Education reviewed the quality of the textbooks by identifying their features and distinctive units. In 2010, the central education authority conducted a questionnaire survey to assess the perceptions of students and teachers of the new textbooks. This paper describes briefly the features of the primary school science textbooks and the perceptions of pupils and teachers based on the conclusions of the above review and survey.

Features of School Science Textbooks in China

Five features distinguish the new primary science textbooks from the former Nature textbook in China.

Firstly, the idea of inquiry learning has become the core of all the new primary science textbooks.

- Rather than describing the natural phenomena or mentioning abstract scientific concepts, laws, principles or other scientific knowledge, the new science textbooks were designed to create a proper atmosphere and environment to promote inquiry learning so as to help students learn systematically the key procedures and skills of inquiry and experience the processes of inquiry and problem-solving.
- Observations, experiments (hands-on activities) and other activities are not treated only as additional facilitations to help students to understand the content knowledge as they used to be; rather, textbook contents are selected and organized according to their roles and effects in inquiry learning.
- A variety of ways have been used to motivate students to engage in inquiry learning activities.
    - Interesting and attractive topics are chosen as learning tasks.
    - Proper "match-and-mismatch" levels are set to make the tasks worthwhile and learnable to students.
    - Each set of the textbooks includes one or two activities that expands over the duration of the course to keep students' attention and enthusiasm in learning.
- Most of the learning activities relate closely to students' daily life experiences and are of medium difficulty.
- Necessary facilitations, such as knowledge and skills relating to the activities, are offered to help student learning.
- Some of the textbooks also include the drilling of inquiry skills in a series of games.

Secondly, all the textbooks aim to present scientific knowledge to students clearly and systematically.

- Each set of textbooks has a framework for presenting the knowledge contents. The framework includes two parallel themes: one for organizing the inquiry activities, another for building the knowledge contents.

Great effort was made to integrate these two themes into one but was not always successful.

- In some cases, the theme for organizing inquiry learning also becomes the way to present knowledge contents.
- The textbooks also pay attention to the ways the knowledge contents are presented. Various strategies, such as games, discussions, demonstrations, and experiments (hands-on activities), are used for presenting scientific knowledge.
- Lively and interesting things or phenomena that relate closely to student daily life are used as the medium for introducing knowledge.
- Daily life knowledge that is important to students and correlate with modern science and technology are also included in the textbooks.

Thirdly, the role of science textbook has changed from an instruction tool for teachers to a tool for both learning and teaching.

- Since student motivation is commonly recognized as the most important thing in teaching and learning, it is strongly featured in presenting knowledge contents or organizing learning activities.
- Besides, the thinking and logic underlying structural scientific knowledge are both taken into account.
- The abstraction and precision of the texts are carefully controlled so that students could understand without difficulty.

Fourthly, learning in science is integrated with other subject matters, especially those with both science and social contents. This includes knowledge and skills in other subject areas, stories of the history of science and great scientists, the STSE issues, ethics and moral issues that arise in the process of scientific development, issues relating to appreciation of the beauty of nature and science. This creates a friendly and harmonious atmosphere and fun for learning.

Fifthly, a number of textboxes are used in science textbooks to add information or activities that enrich and extend students' learning experience. The old textbooks were drab and dull and included only written texts and exercises and a small number of illustrative figures. However, all the new textbooks make use of textboxes. These contents in these textboxes are designed to challenge students, to offer supplementary knowledge, to provide students with necessary skills, to help students to review and assess their learning process and outcomes, and to extend student learning through the internet, etc..

Student and Teacher Perceptions of The New Primary Science Textbooks

In order to learn how students and teachers viewed the new primary science textbooks, the Chinese Ministry of Education conducted a questionnaire survey in over 20 counties/districts in 11 provinces in China in 2010. 9,689 primary students and 387 primary science teachers participated in this survey. The results of the survey are summarized below.

1. The general acceptance of the primary science textbooks by students was very high.

- An average of 3.46 (full score 4) on the appreciation of the textbooks
- An average of 3.36 (full score 4) on helpfulness of learning of the textbooks
- An average of 3.33 (full score 4) on the overall perception of the textbooks
- The difficulty of the textbooks was medium (3.68 in a 5-point scale).

2. Further assessment of the items in the questionnaire suggested:

(1) Experiments (hands-on activities) were the most welcome tasks to students (3.71 in a 4 point scale). Writing exercises were the least wanted tasks (3.11 in a 4-point scale).

(2) While the role of classroom demonstrations were highly valued (3.53 in a 4-point scale), the role of textbooks in assisting students in their out-of-class learning was relatively poorly recognized (3.15 in a 4-point scale).

(3) Students highly agreed that they should keep the textbook even after they finish the course. This reflects a very positive attitude to the textbooks (3.48 in a 4-point scale). However, students felt the wording of the texts was not as good as they expected (3.21 in a 4-point scale).

(4) Figures in the textbooks were the most welcomed and easiest to understand (4.13 in a 5-point scale). Experiments (hands-on activities) in the textbooks were considered the most difficult tasks (2.75 in a 5-point scale).

3 . Different set of the textbooks were perceived differently by the teachers. The scores ranged from 3.2 to 4.2 in a 5-point scale. The average score was 3.97 in a 5-point scale. This means that teachers' perceptions of the textbooks varied from fairly well to very well. The mean scores of the teachers' responses were:

- 4.18 in "compliance with the curriculum standards";
- 4.16 in "facilitation in cultivating students towards the scientific attitude and spirit";
- 4.04 in "the appropriateness of the amount of textbook contents";
- 3.95 in "relating the teaching-learning contents with students' daily life experience;
- 4.00 in "reflecting the progress of science and technology and everyday life";
- 4.05 in "effective in promoting students".

All these average scores were very high in a 5-point scale.

4. The teachers' responses suggest that each set of textbooks has its own style and features which distinguish them from the others.

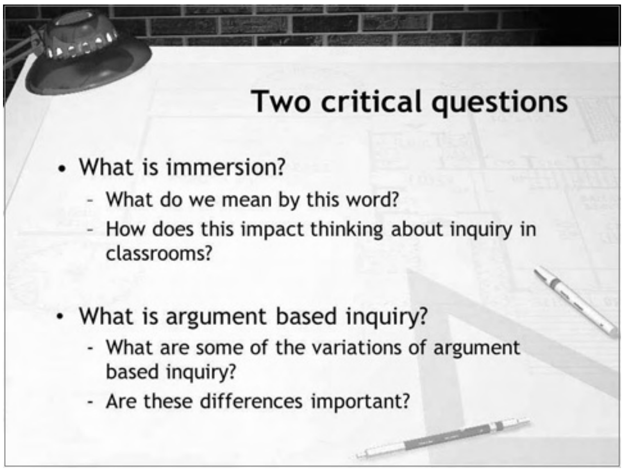
5. The teachers also highlighted a number of problems commonly exist in the textbooks.

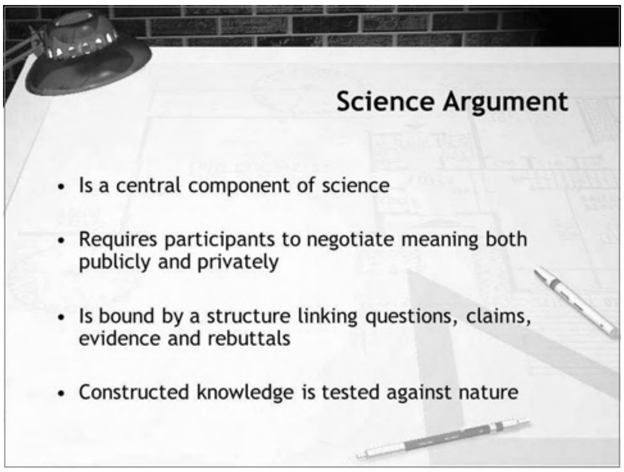
(1) How to educate students with the evolutional tradition of the CP.
(2) How to adapt to the social and economic conditions, educational resources, and to meet the needs of students of different levels.
(3) How to design student experiments (hands-on activities) and make them not too difficult.
(4) How to write the text properly to match the reading capacity of students.
(5) How to match the professional and academic levels of the primary science teachers when 2/3 of them did not major in science.

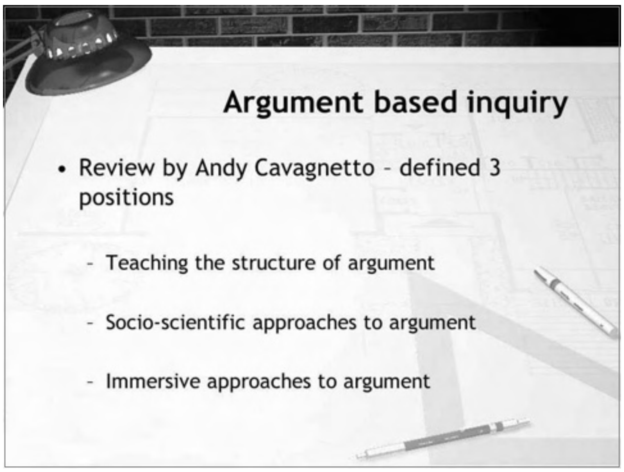
- Invited Speech 3
- Date: Wednesday, October 26, 2011
- Time: 13:00 ~ 14:00
- Room: #2 (1F)
- Chair: Alice S. L. Wong (The University of Hong Kong, Hong Kong)

AN IMMERSION APPROACH TO ARGUMENT BASED INQUIRY - DOES IT LOOK THE SAME IN DIFFERENT COUNTRIES?

Brian Hand
University of Iowa, USA







Science Argument

- Is a central component of science
- Requires participants to negotiate meaning both publicly and privately
- Is bound by a structure linking questions, claims, evidence and rebuttals
- Constructed knowledge is tested against nature

Argument based inquiry

- Review by Andy Cavagnetto – defined 3 positions
  - Teaching the structure of argument
  - Socio-scientific approaches to argument
  - Immersive approaches to argument

Critical Issues that need to be engaged with

- We do not pay enough attention to ideas such as data, evidence, explanation
- Researchers use such ideas – as published in articles
  - Data/evidence
  - Claims, evidence, reasoning
  - Evidence and explanations

Data and Evidence

- Is this distinction important?
  - Students have trouble separating these two
  - “Data does not speak”
  - We have to do something with data to get to evidence

Evidence and Reasoning

- If we have to do something to data to get evidence - what is it?
- Critically we have to reason about the data - we have to make critical decision about
  - What data points to use?
  - Are there patterns?
- If we remove reasoning from evidence we have data

Evidence and Explanation

- Simply question – if evidence is not an explanation – what is it?
- Is not evidence a reasoned explanation about particular data points and how they fit together?
- All evidence is explanatory, but not all explanations are evidentiary

How do these two positions play out in argument based inquiry

- Jonathon Osborne's IDEAS project
  - Used the work of Halliday and Martin which has focused on students having to "learn the language of science" prior to using the language
  - Means that students have to learn the structure of argument before they use it

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- The Science Writing Heuristic approach is based on earlier Halliday work (70's)

You learn about language while you learn through using language

- Means that students

learn about argument while they learn through using argument

Importance?

- These distinctions are not trivial
- There is a distinctly different orientation to the learning of argument based inquiry
- Is it something "done to" students or something students should "be immersed" in?

Criteria for immersion?

- Current work – is focused on issues of alignment
- Four areas that need to be addressed:
  - Learning
  - Epistemic Orientation
  - Language
  - Pedagogy

Learning

- Learning – what is necessary for alignment
- Our focus is on learning not teaching – means we have to address the issue of "what theory of learning"
- We have adopted a "cognitive theory" view – students construct knowledge for him/herself
- Learning is about negotiation

Learning

- Yet to see different learning theories depending on the country or culture
- If we focus on learning – then requires that we start where students are at
- Learning is about negotiation thus we have to negotiate with students

Epistemology of Science

- The advancement of science is about a process of construction and critique
- Scientist negotiate with each other
- Scientists do not advance science through information transfer

  - if this was the case who gave the first scientists the information to pass on?

  - who gives the current generation of scientist the "new" knowledge

Language

- As discussed above – there is no science without language
- Simple task – go teach a science lesson without any forms of language!!!
- Language is required for negotiation – with each other (talking), with text (reading), with constructing text (writing)

Pedagogy

- This criteria is the linking criteria for the other three
- The orientation we adopt for the other three criteria will shape how we create learning environments
- You cannot be misaligned and still have an immersion approach to learning

Problem examples

- Ask most science educators – what is science?
  - Most will have a view that is in line with current thinking
- Ask the same educators – what is learning?
  - Most will define learning in terms of teaching
  - Most will define learning in terms of student acquisition of knowledge

Problem examples

- Ask them about the pedagogy adopted
  - Is in essence an information transfer view
  - Students need to have this important "stuff"
- Curriculum developers – focus on something that has to be done to students

Linking teaching of science to learning of science

- Requirement to "learn the language of science" and to use "language as a learning tool"

  - means that we need to provide opportunities to engage with the language of the content knowledge and the language of argument

- Requirement to engage in "argument as a means to learn science"

  - means that we have to provide opportunities to practice negotiation, both publicly and privately, in constructing and critiquing science knowledge

Framed within Learning

- If we have to learn language by using language, and learn argument by using argument then

  Learning has to be about negotiation

Learning and Teaching

- If learning is about negotiation – then teaching has to be about negotiation

- Fundamentally - if we believe in cognitive approaches to learning then we have to focus on teaching being about negotiation

Teaching

- We do not control what goes on inside someone's head
- We have to negotiate – about the big ideas of the topic
- We have to provide information when it is needed – not as a precursor to all learning
- We have to setup non threatening learning environments
- We have to get out of the way of the negotiations
- We have to learn how to both monitor and enter into negotiations

Our Immersion approach

- The Science Writing Heuristic approach is not something that is done occasionally in science – it is how science is done
- Students are constantly negotiating (when are they not negotiating?)
- Are approach attempts to fully align the four criteria as outlined
- We are not focused on pretend situations, or some societal based problem – we are focused on learning the fundamental concepts of science

---

- We are focused on engaging students in how the store knowledge – the big ideas of topics

- Students have to pose questions, gather data, construct claims based on evidence, test their ideas against what others say (scientists, peers), and reflect on how their ideas have changed

- Students have to critique their own and others ideas

The Science Writing Heuristic Templates

Teacher's template

- Exploration of pre-instruction understanding
- Pre-laboratory activities
- Laboratory activity
- Negotiation I - individual writing
- Negotiation II - group discussion
- Negotiation III - textbook and other resources
- Negotiation IV- individual writing
- Exploration of post-instruction understanding

Student's template

- **Beginning questions or ideas**
  What are my questions about this experiment?
- **Tests and Procedures**
  What will I do to help answer my questions?
- **Observations**
  What did I see when I completed my tests and procedure?
- **Claims**
  What can I claim?
- **Evidence**
  What evidence do I have to support my claim? How do I know? Why am I making these claims?
- **Reading**
  How do my ideas compare with others?
- **Reflection**
  How have my ideas changed?

Comparison across countries – are we getting parallel results

USA – school setting

- An analysis of students' performance on critical thinking test
- Completed across a 2 year period
- Elementary school students – years 5 and 6

Cohen d Effect Size

Group	Year I				Year II			
	SWH		Control		SWH		Control	
	Cohen d	Scale	Cohen d	Scale	Cohen d	Scale	Cohen d	Scale
Total	0.811	Large	0.320	Small	0.630	Medium	0.187	No effect
IEP	0.765	Medium	0.048	No effect	0.430	Small	0.011	No effect
Low SES	0.688	Medium	0.467	Small	0.661	Medium	0.284	Small
Male	0.698	Medium	0.322	Small	0.684	Medium	0.107	No effect
Female	0.882	Large	0.315	Small	0.581	Medium	0.246	Small

Subscale

Group	Critical Thinking	Year I			Year II		
		N	M	SD	N	M	SD
SWH	Total	328	6.03	6.62	316	4.37	6.16
	Induction	328	1.63	3.53	316	1.4	3.30
	Deduction	328	2.91	3.94	316	1.52	3.32
	Observation	328	1.55	3.45	316	1.73	3.44
	Credibility	328	1.55	3.45	316	1.73	3.44
	Assumption	327	0.95	2.27	316	0.37	1.97
Control	Total	211	2.61	6.06	197	1.86	7.56
	Induction	211	0.87	3.32	198	0.74	3.31
	Deduction	211	0.97	3.56	198	0.61	4.01
	Observation	211	0.77	2.83	198	0.36	2.98
	Credibility	211	0.77	2.83	198	0.36	2.98
	Assumption	211	0.34	1.88	198	0.15	2.34

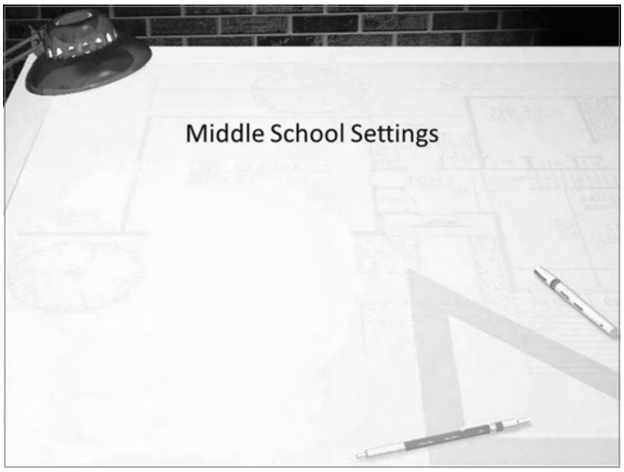
Critical Thinking Score Based on Students' ITBS Score

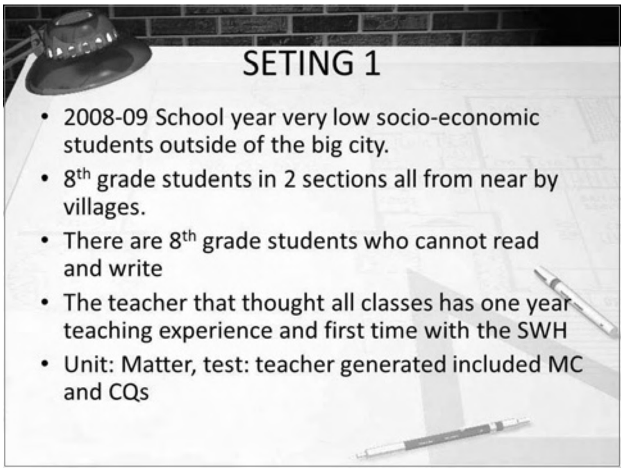
Group	ITBS Science Level	Critical Thinking	Year I			Year II		
			N	M	SD	N	M	SD
SWH	Low	Pre-test	111	35.47	6.43	79	36.59	6.68
		Post-test	111	41.7	7.08	79	41.19	7.86
		Gain Score	**102**	**5.82**	**7.13**	**79**	**4.03**	**6.98**
	Medium	Pre-test	116	40.39	5.61	122	42.07	6.78
		Post-test	113	46.77	5.85	122	46.84	6.46
		Gain Score	**108**	**6.57**	**6.36**	**122**	**4.62**	**6.14**
	High	Pre-test	106	45.73	6.24	78	46.63	6.89
		Post-test	109	51.49	6.08	78	52.13	5.33
		Gain Score	**104**	**5.89**	**6.68**	**78**	**5.36**	**5.53**
Control	Low	Pre-test	78	37.67	7.12	64	38.67	8.15
		Post-test	64	39.64	8.30	64	41.75	9.05
		Gain Score	**63**	**1.33**	**6.60**	**64**	**2.9**	**6.36**
	Medium	Pre-test	77	41.27	7.42	45	44.4	6.18
		Post-test	79	44.62	7.34	45	46.24	7.33
		Gain Score	**71**	**3.24**	**5.91**	**45**	**1.84**	**7.26**
	High	Pre-test	74	48.03	7.13	71	46.83	8.17
		Post-test	78	51.13	6.72	71	46.97	8.18
		Gain Score	**72**	**2.65**	**5.44**	**71**	**0.13**	**6.46**

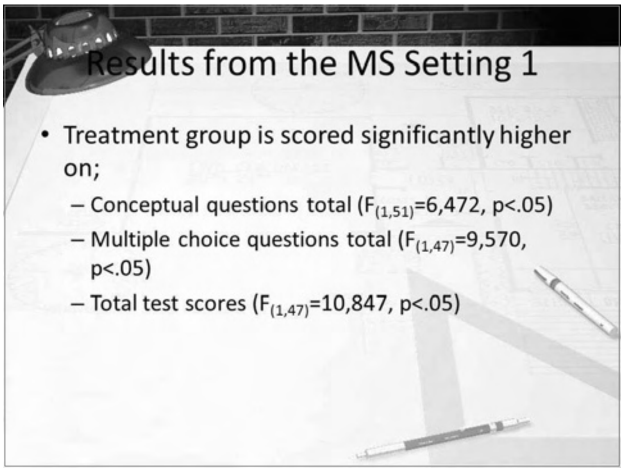
Critical Thinking Score Based on Level of Teacher's Implementation

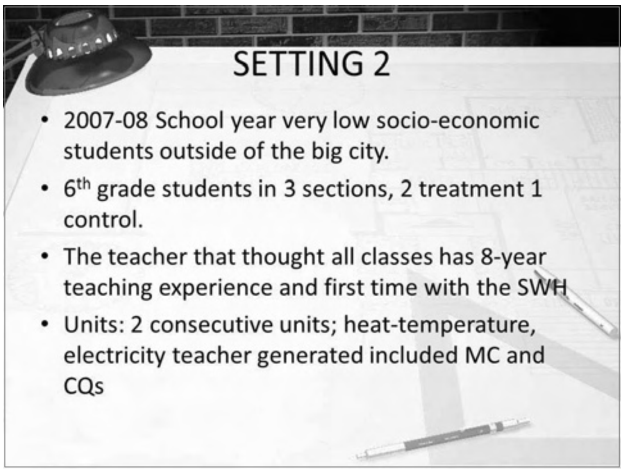
Group	RTOP	Critical Thinking	Year I			Year II		
			N	M	SD	N	M	SD
SWH	Low	Pre-test	58	40	6.77	31	38.26	6.73
		Post-test	55	43.36	7.58	31	44.35	8.97
		Gain Score	**55**	**3.47**	**5.96**	**31**	**4.61**	**6.60**
	Medium	Pre-test	262	40.71	7.40	150	43.01	7.95
		Post-test	266	47.35	7.31	150	47.23	7.59
		Gain Score	**247**	**6.6**	**6.78**	**150**	**4.12**	**6.50**
	High	Pre-test	14	36.79	8.22	100	40.93	7.34
		Post-test	13	45.31	7.26	100	46.52	7.68
		Gain Score	**13**	**8**	**5.72**	**100**	**5.38**	**5.67**

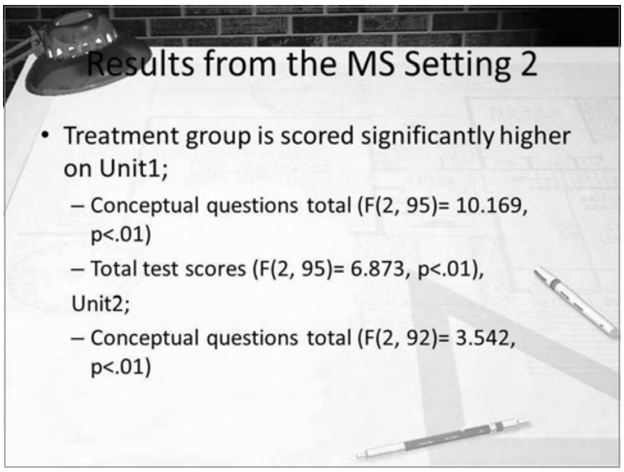

RESULTS OF TURKISH SWH STUDIES

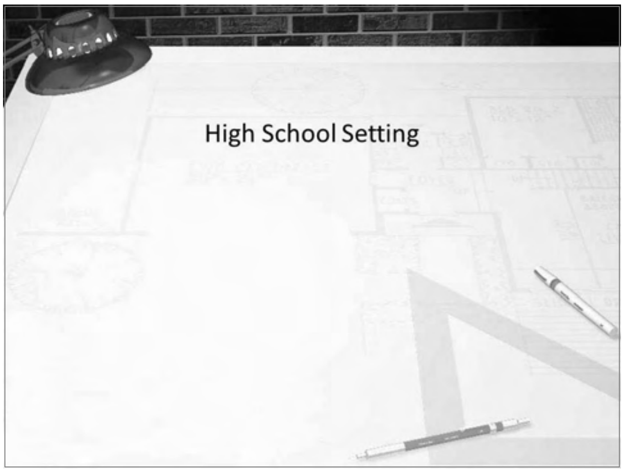

Middle School Settings

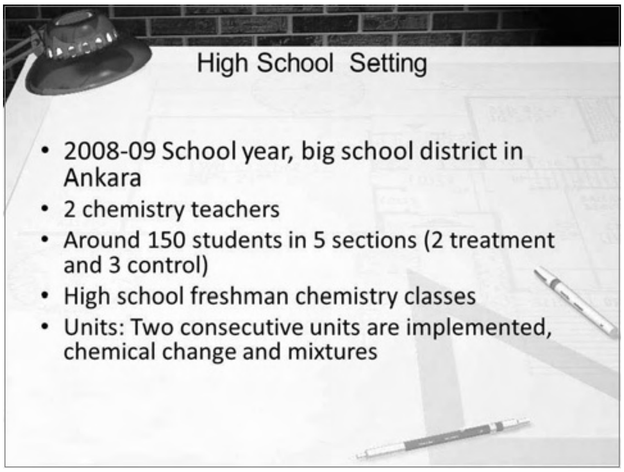

SETING 1
• 2008-09 School year very low socio-economic students outside of the big city.
• 8th grade students in 2 sections all from near by villages.
• There are 8th grade students who cannot read and write
• The teacher that thought all classes has one year teaching experience and first time with the SWH
• Unit: Matter, test: teacher generated included MC and CQs

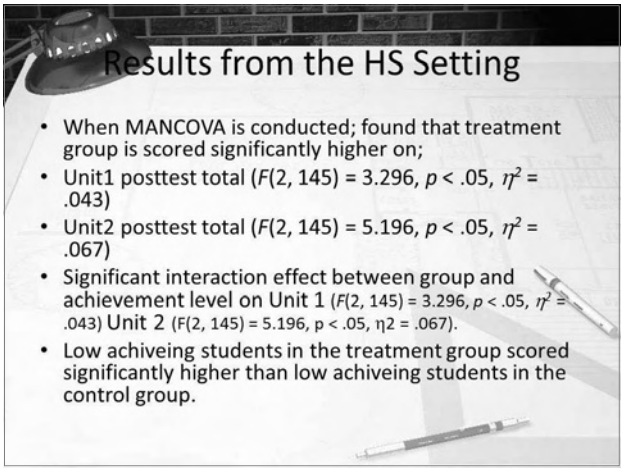

Results from the MS Setting 1
• Treatment group is scored significantly higher on;
– Conceptual questions total ($F_{(1,51)}$=6,472, p<.05)
– Multiple choice questions total ($F_{(1,47)}$=9,570, p<.05)
– Total test scores ($F_{(1,47)}$=10,847, p<.05)

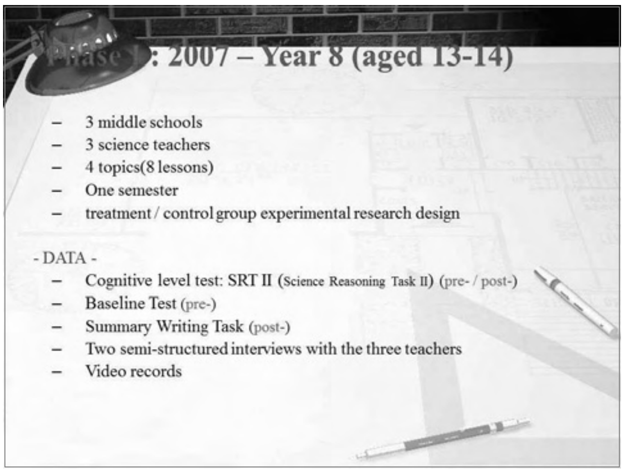

SETTING 2
• 2007-08 School year very low socio-economic students outside of the big city.
• 6th grade students in 3 sections, 2 treatment 1 control.
• The teacher that thought all classes has 8-year teaching experience and first time with the SWH
• Units: 2 consecutive units; heat-temperature, electricity teacher generated included MC and CQs

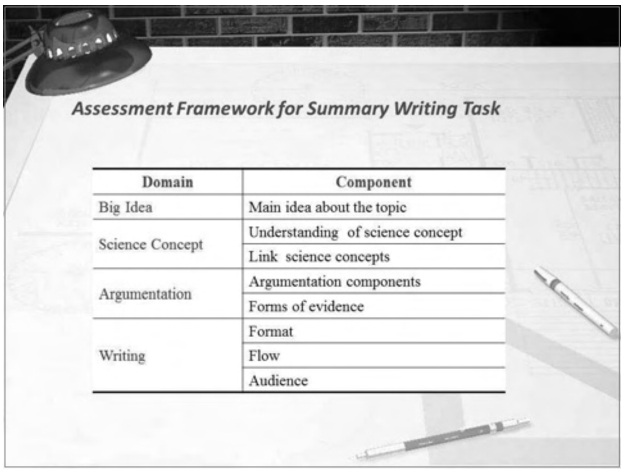

Results from the MS Setting 2
• Treatment group is scored significantly higher on Unit1;
– Conceptual questions total (F(2, 95)= 10.169, p<.01)
– Total test scores (F(2, 95)= 6.873, p<.01),
Unit2;
– Conceptual questions total (F(2, 92)= 3.542, p<.01)










Assessment Framework for Summary Writing Task

Domain	Component
Big Idea	Main idea about the topic
Science Concept	Understanding of science concept
	Link science concepts
Argumentation	Argumentation components
	Forms of evidence
Writing	Format
	Flow
	Audience

2007 – Year 8 (aged 13-14)

on Science Reasoning ability , Summary Writing

- Participants -

School	A	B	C	Total
Grade	8th	8th	8th	
Teaching Experience	23 years	13 years	3 years	
Number of Students in the SWH Group	66	65	58	189
Number of Students in the Control Group	32	66	58	156
Number of Students in Total	98	131	116	345

Study I : 2007 – Year 8 (aged 13-14)

	Teacher A		Teacher B		Teacher C	
	Treatment	Control	Treatment	Control	Treatment	Control
SRT II	4.74	4.56	4.84*	4.42	4.22	4.53
SWT	21.14*	14.34	28.45*	19.82	16.74	16.12
Big idea	3.41	2.66	7.00*	4.94	3.28	3.66
Science concept	3.44	2.69	4.66*	3.36	2.26	2.44
Argumentation	5.42*	3.00	7.68*	4.45	3.21	2.71
Writing	8.85*	5.81	8.86*	7.15	7.97	7.69

07 – Year 8 (aged 13-14)

mentation level of SWH by RTOP

- Results-

Implementation level of SWH by RTOP

RTOP		A	B	C
Student Voice	SWH	5	7	2
	Control	2	2	1.7
Teacher Role	SWH	2.7	2	1.7
	Control	2.7	1.7	1.3
Science Argument	SWH	5.3	6.3	3.3
	Control	3.3	4	3.3
Questioning	SWH	1	1	0.7
	Control	2	1	1.3
Total	SWH	14	16.3*	7.7
	Control	10	8.7	7.6

Phase II : 2008 – Year 7, 8, 9 (aged 12-15)

Study I : Impact on Science Reasoning ability , Summary Writing, and Argumentation

- 5 middle schools / 5 science teachers
- 9 topics(18 lessons) / 1 year
- treatment / control group experimental research design

- Data -

- SRT II (Science Reasoning Task II) (pre- / post-)
- National Achievement Test (pre- / post-)
- Argumentation Task (pre- / post-)
- Summary Writing Task (pre- / post-)

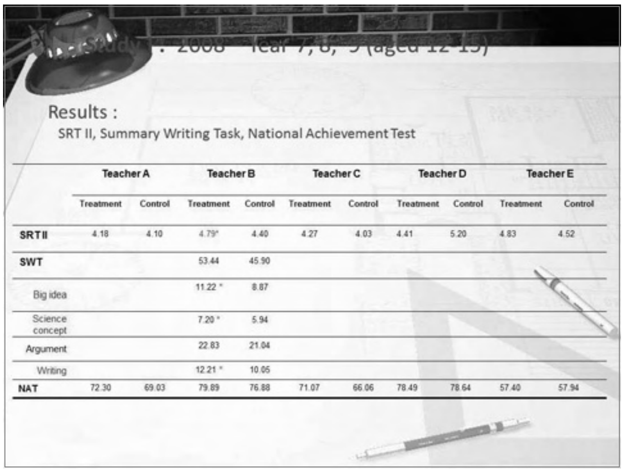
ent Framework for Argumentation Task

Domain	Component
Structure of argumentation	• structure of whole argumentation • structure of unit argumentation
Validity of argument	• validity of conclusion • validity of evidence • validity of rebuttal
Use of argument component	• frequency of argument component

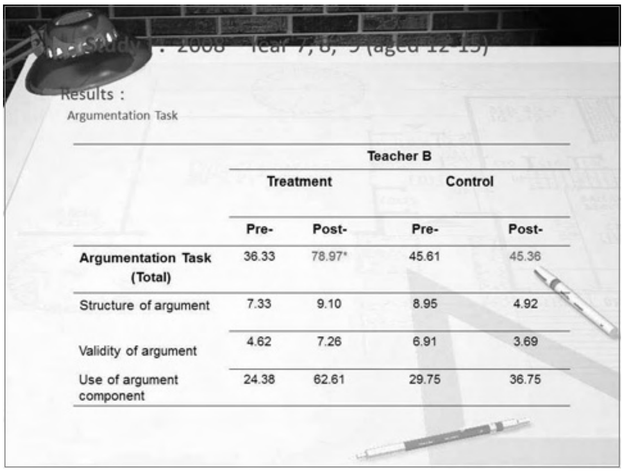
: 2008 – Year 7, 8, 9 (aged 12-15)

- Participants -

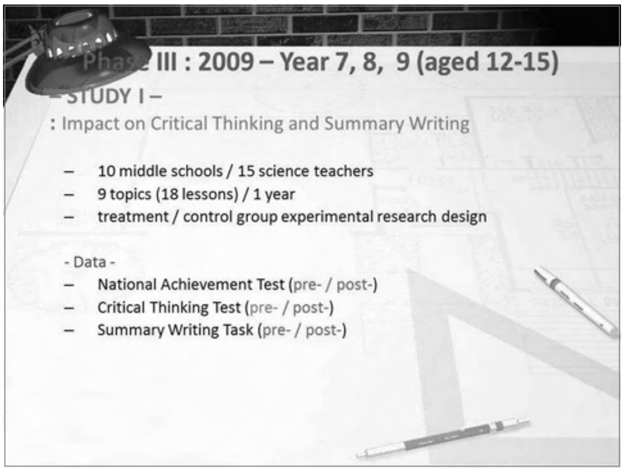
School	A	B	C	D	E	Total
Grade	7th	7th	7th	8th	9th	
Time period	4 months	1 year	1 year	1 year	1 year	
Number of Students (SWH Group)	67	64	56	66	69	322
Number of Students (Control Group)	64	34	57	34	34	223
Number of Students (Total)	131	98	113	100	103	545

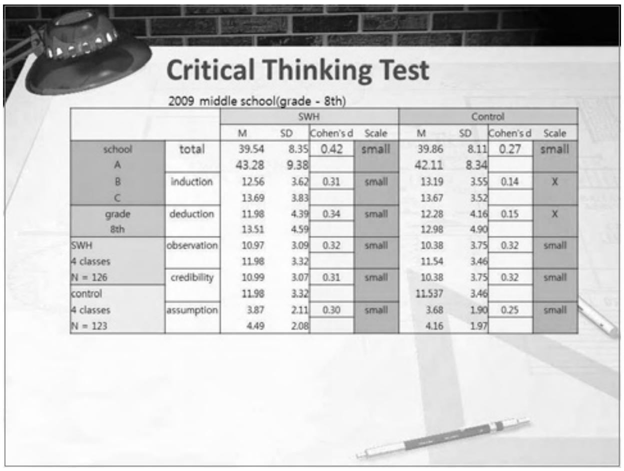


	Teacher A		Teacher B		Teacher C		Teacher D		Teacher E	
	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
SRT II	4.18	4.10	4.79*	4.40	4.27	4.03	4.41	5.20	4.83	4.52
SWT			53.44	45.90						
Big idea			11.22 *	8.87						
Science concept			7.20 *	5.94						
Argument			22.83	21.04						
Writing			12.21 *	10.05						
NAT	72.30	69.03	79.89	76.88	71.07	66.06	78.49	78.64	57.40	57.94

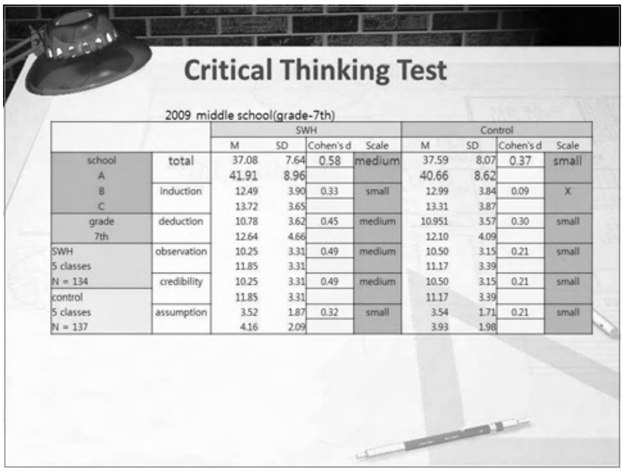


	Teacher B			
	Treatment		Control	
	Pre-	Post-	Pre-	Post-
Argumentation Task (Total)	36.33	78.97*	45.61	45.36
Structure of argument	7.33	9.10	8.95	4.92
Validity of argument	4.62	7.26	6.91	3.69
Use of argument component	24.38	62.61	29.75	36.75

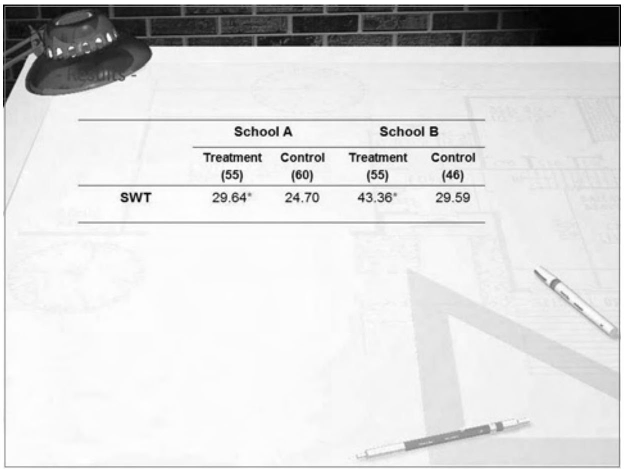




		SWH				Control			
		M	SD	Cohen's d	Scale	M	SD	Cohen's d	Scale
school	total	39.54	8.35	0.42	small	39.86	8.11	0.27	small
A		43.28	9.38			42.11	8.34		
B	induction	12.56	3.62	0.31	small	13.19	3.55	0.14	X
C		13.69	3.83			13.67	3.52		
grade	deduction	11.98	4.39	0.34	small	12.28	4.16	0.15	X
8th		13.51	4.59			12.98	4.90		
SWH	observation	10.97	3.09	0.32	small	10.38	3.75	0.32	small
4 classes		11.98	3.32			11.54	3.46		
N = 126	credibility	10.99	3.07	0.31	small	10.38	3.75	0.32	small
control		11.98	3.32			11.537	3.46		
4 classes	assumption	3.87	2.11	0.30	small	3.68	1.90	0.25	small
N = 123		4.49	2.08			4.16	1.97		



		SWH				Control			
		M	SD	Cohen's d	Scale	M	SD	Cohen's d	Scale
school	total	37.08	7.64	0.58	medium	37.59	8.07	0.37	small
A		41.91	8.96			40.66	8.62		
B	induction	12.49	3.90	0.33	small	12.99	3.84	0.09	X
C		13.72	3.65			13.31	3.87		
grade	deduction	10.78	3.62	0.45	medium	10.951	3.57	0.30	small
7th		12.64	4.66			12.10	4.09		
SWH	observation	10.25	3.31	0.49	medium	10.50	3.15	0.21	small
5 classes		11.85	3.31			11.17	3.39		
N = 134	credibility	10.25	3.31	0.49	medium	10.50	3.15	0.21	small
control		11.85	3.31			11.17	3.39		
5 classes	assumption	3.52	1.87	0.32	small	3.54	1.71	0.21	small
N = 137		4.16	2.09			3.93	1.98		



	School A		School B	
	Treatment (55)	Control (60)	Treatment (55)	Control (46)
SWT	29.64*	24.70	43.36*	29.59

- Invited Speech 4
- Date: Wednesday, October 26, 2011
- Time: 13:00 ~ 14:00
- Room: #3 (1F)
- Chair: Hye-Gyoung Yoon (Chuncheon National University of Education, Korea)

LIGHTING THE WORLD WITH SCIENCE: LESSONS FROM THE ROLE OF SCIENCE IN THE EUROPEAN ENLIGHTENMENT

Michael R. Matthews
University of New South Wales, Australia

Abstract

A common feature of contemporary science education curricula is the expectation that as well as learning science content, students will learn something about science - its nature, its history, and its interactions with culture and society. And the expectation is that such learning will contribute to people being more scientific, to them having a scientific habit of mind, and to having a more scientific approach to natural, social and cultural problems. This paper will discuss an important aspect of science's contribution to culture, namely its role in the formation of the European Enlightenment, and its continued support for and interdependence on this tradition of philosophical, religious, political and social thought. It was the new method of 17th century science that bore the hopes of the Enlightenment for progress in understanding across the whole spectrum of human affairs. Methodological changes how people went about assessing knowledge claims were not the only thing initiated by the Scientific Revolution: the new science (natural philosophy) also caused a massive change in Western philosophy that had enduring repercussions for religion, ethics, politics and culture. The Enlightenment was part of this philosophical change. The Scientific Revolution was the seed from which the Enlightenment plant grew. By utilising Pope Pius IX's Syllabus of Errors (1864) encyclical, Ten Core principles of Enlightenment Ideology are delineated and defended.

A common feature of contemporary science education curricula is the expectation that as well as learning science content, students will learn something about science - its nature, its history, and its interactions with culture and society. As well as science disciplinary and knowledge goals, contemporary science curricula have cultural or humanistic goals. Frequently the term 'Nature of Science' or NOS is given to this curricular objective. The position was elaborated in the AAAS publication *The Liberal Art of Science:*

> *The teaching of science must explore the interplay between science and the intellectual and cultural traditions in which it is firmly embedded. Science has a history that can demonstrate the relationship between science and the wider world of ideas and can illuminate contemporary issues. (AAAS 1990, p.xiv)*

This paper will discuss an important historical contribution of science to culture, namely science's role in the formation of the European Enlightenment, and its continued support for and interdependence on this tradition of philosophical, religious, political and social thought.

A New Science and a New Method

The achievements of the 17^{th} century Scientific Revolution in fields such as anatomy, astronomy, mechanics, hydraulics, pneumatics and optics were obvious, impressive and widely known. The natural philosophers themselves, and other philosophers and scholars, were immediately concerned to lay bare and systematise the procedure or method used by Copernicus, Kepler, Galileo, Torricelli, Pascal, Huygens, and the 'incomparable' Isaac Newton, that enabled these new discoveries about nature. Many asked: What were the new natural philosophers doing differently from medieval and renaissance Aristotelians? These were important *internal* questions about the procedures of the new science. Additionally some philosophers attempted to identify the *external* circumstances that allowed and encouraged the new science and hence its wide-ranging discoveries. Some asked: What were the social, cultural, legal or educational circumstances that enabled and encouraged the practice of the new science, and conversely were there such factors that inhibited the growth and spread of the new science and its method?

That the New Science was dependent upon a New Method was widely recognised. William Gilbert (1544-1603), at the beginning of the Scientific Revolution, in the Preface to On the Loadstone (1600), is explicit that his science is associated with a new methodology, or 'style of philosophizing', as he calls it. He writes:

> *To you alone, true philosophers, ingenuous minds, who not only in books but in things themselves look for knowledge, have I dedicated these foundations of magnetic science - a new style of philosophizing. (Gilbert 1600/1952, p.1)*

On account of both historical development and diversity of subject matter, one needs to be cautious about identifying any single account of methodology as *the* method of the New Science. Nevertheless it is instructive to lay out how learned opinion, at the time, characterised the new methodology; and then with hindsight to elaborate the enduring methodological principles that came characterised the mature New Science.

What were the Methodological Innovations of the Scientific Revolution?

There is still considerable scholarly disagreement about what constituted the central methodological elements of the New Science. This is not the place to settle any of these disputes, but the following can be put forward as defendable elements of the new scientific method that was launched by Galileo and perfected by Newton, the Galilean-Newtonian Paradigm (GNP).

1. Experimentalism. The long-standing Aristotelian injunction about not interfering with nature if we want to understand her was rejected first by Galileo, with his famous inclined plane experiments conducted so as to understand the phenomena of free fall, then progressively by the other foundation figures, most notably Newton with his pendulum experiments in mechanics and his prism manipulations in optics. It was this newly introduced experimentalism that occasioned Kant to remark that:

> *When Galileo caused balls, the weights of which he had himself previously determined, to roll down an inclined plane; when Torricelli made the air carry a weight which he had calculated beforehand to be equal to that of a definite volume of water … a light broke upon all students of nature. They learned that reason has insight only into that which it produces after a plan of its own, and that it must not allow itself to be kept, as it were, in nature's leading-strings (Kant 1787/1933, p.20)*

2. Idealisation. Galileo was the first to build idealisation into the investigation of nature, and it was this methodological move that enabled his New Science to emerge. What Galileo recognised was that nature's laws were not found in nature; they were not given in immediate experience; the laws applied only to idealised circumstances. This employment of idealisation was also in flat contradiction to the long empiricist Aristotelian tradition whereby 'science' was to be about the world as seen and experienced. In contrast, Galileo immediately after proving his famous Law of Parabolic Motion, says:

> *I grant that these conclusions proved in the abstract will be different when applied in the concrete and will be fallacious to this extent, that neither will the horizontal motion be uniform nor the natural acceleration be in the ratio assumed, nor the path of the projectile a parabola. (Galileo 1638/1954, p. 251)*

3. Mathematisation. Galileo contradicted the Aristotelian tradition by bringing mathematics into science or natural philosophy; he used Archimedean mathematical reasoning in the depiction and analysis of brute events. Thus his patron Guildabaldo del Monte said of Galileo's pendulum discoveries that they were 'great mathematics but terrible physics'. Despite a tradition of 'mixed sciences' (optics, astronomy and harmonics mainly), the Aristotelian tradition simply did not believe that it was appropriate to use mathematics in the investigation of nature. Galileo utilised geometry and proportional reasoning in his mechanics, Huygens pushed both further, and Newton with his densely geometric Principia *Mathematica* (1687) laid the foundations of modern science.

The Philosophical Revolution

Methodological changes how people went about assessing knowledge claims were not the only thing initiated by the Scientific Revolution: the new science (natural philosophy) also caused a massive change in Western philosophy, that had enduring repercussions for religion, ethics, politics and culture. The Scientific Revolution gave birth to Early Modern Philosophy, an intellectual movement in opposition to the then dominant Scholasticism of European philosophy. The Enlightenment movement was part of this philosophical upheaval and most consciously associated itself with and drew its inspiration from natural philosophers who were crafting the New Science.

It is well known that the early modern philosophers – Bacon, Hobbes, Locke, Hume, Leibniz, Kant, the French *philosophes* – forged their philosophy in the light of the new science. What is less appreciated is that the scientists were themselves philosophers, and laid out the central ontological and epistemological positions developed by the above early modern philosophers and around which the subsequent history of Western philosophy revolved. Galileo, Descartes, Huygens, Boyle and NewtonallrejectedAristotelianismintheirscientificpractic eandintheirenunciatedphilosophy. Overwhelmingly the new philosophy was corpuscularian, mechanical and realist – it has rightly been called the 'Mechanical World View'. In this new world view, there was simply no place for the entities that Aristotelianism utilised to explain events in the world: immaterial substances, natures, substantial forms, qualities and final causes were all banished. As many have remarked this largely meant that in natural philosophy (science) *Why* questions (of a teleological kind) were banished and replaced with *How* questions (of a descriptive kind).

The Enlightenment and the New Philosophy

The Enlightenment began as a part of the New Philosophy, but quickly spread way beyond the debates and concerns of philosophy. The Enlightenment was forged by philosophers and writers of the 18^{th} century who applied the empirical methodology and critical outlook of the 17^{th} century's New Science, to wider social issues and debates. Jean Lerond d'Alembert's belief in the power of 'right thinking' was such that he thought that if mathematicians were smuggled into Spain the influence of their clear, rational thinking would spread until it undermined the Inquisition (Hankins 1985, p.2). He well captured the thought and enthusiasm of many when, in 1759, he wrote:

> *Our century is called … the century of philosophy par excellence ..The discovery and application of a new method of philosophizing, the kind of enthusiasm which accompanies discoveries, a certain exaltation of ideas which the spectacle of the universe produces in us - all these causes have brought about a lively fermentation of minds, spreading through nature in all directions like a river which has burst its dams. (Cassirer 1932/1951, p.3-4)*

The Enlightenment as an historic force started in England with the publications of John Locke Newton's self-styled 'under-labourer'. In the space of six years (1689-1695) Locke published the influential *Letters on Toleration* (1689), *Essay Concerning Human Understanding* (1689), *Two Treatises of Government* (1690), *Thoughts Concerning Education* (1693), and *The Reasonableness of Christianity* (1695). The Enlightenment programme was further articulated in England (and Scotland) by Hobbes, Hume, Priestley, Gibbon, Smith and others. In the Netherlands it was articulated by Baruch Spinoza, another scientist and philosopher. In France the Enlightenment project was argued by a brace of scientifically-influenced philosophers, notably Voltaire, Rousseau, d'Alembert, Condorcet, Montesquieu and others who collectively were called the *Philosophes*. In Germany it was developed by Wolff, Leibniz, Lessing, Mendelssohn, Kant and others. And across the Atlantic in the newly created United States the Enlightenment was furthered by Franklin, Paine, Jefferson, Adams, Madison, and others. The American Declaration of Independence and the Constitution were both infused with Enlightenment principles.

The 18^{th} century exponents of the Enlightenment have left their imprint on Western political, religious and philosophical thought and institutions. The West is in constant engagement with the Enlightenment. Many people, cultures and institutions have accepted most of the theses of the Enlightenment; others have accepted some of the theses; and many cultures have rejected nearly all of the claims of the Enlightenment. The extent to which non-Western traditions and cultures, specifically the Islamic tradition, can engage with Enlightenment thinking is one of the great geo-political and cultural issues of the current day. In so many ways the intellectual, political, religious, educational directions advocated by champions of the current 'Arab Spring' in Egypt, Tunisia, Libya, Morocco, Bahrain and elsewhere, are repeating and reliving the arguments and struggles of European enlightenment philosophers and movements of the 18th century. So to the many struggles in Islamic countries about the separation of religion and state, especially the application of Sharia law in cases of women's rights and the freedom of religion and religious practice; so to in struggles for democracy and freedom of speech in China. These are all cases of delayed struggles that first occurred in 18^{th} century Europe that were then waged by the champions of Enlightenment thought that was intimately connected to and inspired by the Scientific Revolution.

What was the Enlightenment?

The first step, the historical exercise, is to identify Enlightenment principles; the next step is to appraise them, this is more a philosophical and political exercise. And it is a very contentious exercise: since its inception, the Enlightenment project although widely supported has nevertheless been opposed from orthodox religious perspectives, from conservative and absolutist political perspectives and more recently from postmodernist philosophical perspectives.

The historical exercise is a major undertaking; it involves going through all the authors and texts of the Enlightenment (the placards in the demonstration), and delineating the array of religious, political and philosophical positions that are affirmed; then trying to give some weight to the importance and influence of each at the time. Fortunately this task was undertaken by Pope Pius IX who in 1864 promulgated his *The Syllabus of Errors* in which eighty Enlightenment positions (then identified with Liberalism, Secularism and Democracy) were laid down and condemned.

Pope Pius IX and the Syllabus of Errors (1864)

Early 19^{th} century Europe was shaking with political, religious, social and intellectual ferment. The aftershocks of the French Revolution still agitated the landscape. Conservatives wanted a return to the structures and culture of the reactionary *Ancien Regime* and killed and imprisoned countless thousands in order to so return; Liberals attempted to bring secular liberal democracy, such as could be seen in the youthful Enlightenment-inspired United States, to Europe and especially to the reactionary regimes of Spain, the Papal States, Portugal, the Habsburg Empire, the Ottoman states and Russia; Radicals wanted root-and-branch reform, if not overthrow, of the existing political and social order.

Pope Gregory XVI defended conservatism and reaction. His Encyclical *Mirari vos* (1831) gives some sense of how the major citadel of political and ideological reaction saw the times:

> *5. We speak of the things which you see with your own eyes, which We both bemoan. Depravity exults; science is impudent; liberty, dissolute.*
>
> *15. Here We must include that harmful and never sufficiently denounced freedom to publish any writings whatever and disseminate them to the people, which some dare to demand and promote with so great a clamour. We are horrified to see what monstrous doctrines and prodigious errors are disseminated far and wide in countless books, pamphlets, and other writings which, though small in weight, are very great in malice*

Gregory's worst fears materialised in 1848, two years after his death: Rome was occupied byI talian 'freedom fighters' demanding a united, liberal, democratic, republic an Italy. 1948 was the 'Year of Revolutions'; it was the year that Karl Marx published his The *Communist Manifesto*.

In 1846 Pope Pius IX (Pio Nono) began the longest papal reign in history (1846-1878). In 1864, five years after Darwin's Origin of Species, he issued his *Syllabus of Errors* against Liberalism and the Enlightenment doctrines that were agitating Europe and that had spread to the United States.

Examining some of the listed Errors is an historically and educationally useful reasonable way to appreciate what the Enlightenment stood for. The Enlightenment was committed to all of the 'errors' that Pio Nono identified. Consider for example just a sample:

The Pope condemned all those who believed that:

> *3. Human reason, without any reference whatsoever to God, is the sole arbiter of truth and falsehood, and of good and evil; it is law to itself, and suffices, by its natural force, to secure the welfare of men and of nations.*

The Pope condemned all those who thought:

5. Divine revelation is imperfect, and therefore subject to a continual and indefinite progress, corresponding with the advancement of human reason.

The Pope condemned all those who maintained that:

10. As the philosopher is one thing, and philosophy another, so it is the right and duty of the philosopher to subject himself to the authority which he shall have proved to be true; but philosophy neither can nor ought to submit to any such authority.

Some of the other Errors identified and condemned by Pio Nono were:

14. Philosophy is to be treated without taking any account of supernatural revelation.
15. Every man is free to embrace and profess that religion which, guided by the light of reason, he shall consider true.
40. The teaching of the Catholic Church is hostile to the well- being and interests of society.
47. The best theory of civil society requires that popular schools open to children of every class of the people, …. should be freed from all ecclesiastical authority, control and interference
55. The Church ought to be separated from the .State, and the State from the Church.
57. The science of philosophical things and morals and also civil laws may and ought to keep aloof from divine and ecclesiastical authority.

And last but not least, it was a grave error to hold the view that:

80. The Roman Pontiff can, and ought to, reconcile himself, and come to terms with progress, liberalism and modern civilization.

Each of Pius IX's eighty 'errors' can be traced to Enlightenment sources. In an educational context, one advantage of approaching Enlightenment principles this way is that it puts the teacher a little into the background, and puts historical texts into the foreground. This can take some of the 'heat' out of elucidation and elaboration of the principles.

Ten Principles of the Enlightenment

For any complex historical movement, such as the Enlightenment, there is danger in distilling out its central components: it is easy to read into past movements current priorities and values, and consequently miss nuances and historically important aspects of the movements. The above recourse to Pio Nono's Syllabus of Errors is one way that this risk might be minimised.

The following might be regarded as ten central principles of Enlightenment thinking:

1. Universalism: All normal human beings share a similar nature and consequently are capable of acquiring knowledge, and are equally subject to ethical considerations.

2. Objectivity: On matters of fact, whether particular or general, there is objective truth or falsity

3. Rationality: Individuals are capable in principle of determining the truth or falsity of propositions concerning matters of fact.

4. Empiricism: Sensory evidence is required for the determination of matters of fact.

5. Scientism: The method of the new physical sciences needs to be followed in social, political, moral and religious investigations in order to obtain knowledge in these fields.

6. Anti-Revelationism: The only sound method in theology is that of natural theology; knowledge of God is constrained to what can be reasoned from experience and the natural world. Reason thus judges putative revelations.

7. Naturalism: The only entities existing in the world, and hence capable of explaining events, are those revealed by science. This may or may not entail materialism. Myths and superstitions need to be rejected.

8. Utilitarianism: Ethical norms are to be formulated on the basis of their personal and social utility, not on the basis of revealed religion nor on other putative deontological grounds.

9. Optimism: Human beings, and the human condition, is such that betterment of both can occur by the application of sound reasoning and right conduct.

10. Independence: Secular or religious authorities have no special means to determine truths about the world, ethics, politics or even religion; the claim of individual reason following right method is paramount over mere authoritarian pronouncements.

Many of the achievements of the early Enlightenment have become part of everyday Western common sense. Originally people spelt blood affirming them ‒ separation of Church and State, democratic government, freedom of the press, freedom of religion, etc. ‒ now they are a common-place. Nevertheless it needs be recognised that Enlightenment views came very slowly to many parts of the West and, for example, it is only in the past two decades that Spain, Italy and Ireland have broken the hold of the Catholic Church on national family and educational law. Although Enlightenment causes have made more headway in the secular, democratic, liberal West, the Enlightenment has made less progress in other cultures where absolutism, censorship, subservience of law to religion, and discrimination on basis of gender, caste and class are all still entrenched.

Conclusion

Science has contributed immensely to our philosophical and cultural tradition, this is part of the 'flesh' of science; too often, unfortunately, science teaching presents just the 'bare bones' of science ‒ this is one reason why, notoriously, advanced 'technical' science is so often associated with religious and ideological fundamentalism and bigotry. The cultural flesh needs to be part of any serious science programme, and indeed this is now required in many contemporary curriculum statements.

In a good liberal education students will learn about the philosophical dimensions of science, beginning with the routine matters of conceptual analysis, epistemology, ethics and so on. They will also learn about the metaphysical, especially ontological, dimensions of science, some of which have been discussed above. They should also be introduced to, and hopefully make decisions about the constitution and applicability of the scientific outlook, habit of mind or the scientific temper ‒ is a scientific outlook required for the solution of social and ideological problems? And finally students should engage with the questions of science and worldviews, and study options for reconciling seeming conflicts in this area. All of this makes science classes more intellectually engaging, it promotes 'minds-on' science learning.

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E·A·S·E

- Invited Workshop 1
- Date: Wednesday, October 26, 2011
- Time: 15:20 ~ 16:20
- Room: #1 (1F)
- Chair: Ki-Young Lee (Kangwon National University, Korea)

CHEMICAL EDUCATION FOR CREATIVITY: KNOWLEDGE, JUDGMENT, AND REPRESENTATION

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1. Introduction

It is important for student to have thinking and behaving imaginatively, and finally to have an outcome which is of value to the original objective [1, 2]. Promoting creativity in science has been reported and discussed in papers [3-8]. Actually, international evaluations of PISA [9] and TIMSS [10] show that Japan places still high level in education concerning about the competence of student. However, they simultaneously demonstrate some weak points of i) poor logical thinking, ii) quite little number of student in excellence, and iii) meager creativity. Special interest of ours is devoted to this school education, especially in chemical education. The lessons still in Japan, even in the world, tend to be usually carried on the way of wiggle behavior of student's listening, writing, and answering including testing through a teacher-centered class-lecture. The lessons, we propose, are favored to proceed under the way of dialogue between students and teacher, and of activities of student himself after the former dialogue. The learning on the basis of students' enthusiastic activities over imaginative thinking and behaving would be of great importance to understand science and chemistry.

Our session entitled "Chemical Education for Creativity" will be expected to provide a platform for participants to share and discuss new ideas, techniques and strategies for promoting creativity in science education, especially chemical education. In this paper, chemical education for creativity would be raised and discussed from the aspects of theory and practice, namely a basic conception of creative thinking (by Ogawa) and a lesson model toward promoting students' creativity (by Fujii).

2. Basic Conception of Creative Thinking

We have proposed a fundamental feature of school lesson in science and chemistry in which a Special Emphasis on Imagination leads to Creation (SEIC) [11]. Having imagination is emphasized with the hope of acquiring sufficient knowledge and skills toward promoting creativity in this SEIC program. Development of the lesson models such as rust of iron and surface-active agent through the principle of SEIC has been reported, and the model was effective for students to realize images of the chemical reaction of rust of iron accompanied by an acquisition of sufficient knowledge [12]. Especially, a way of the lesson through drawings was one of the influential methodologies for enhancing images of the chemical reaction, and students felt some importance comparatively to imagination through experiment & observation and application of schemes as an important item for learning methodologies.

2.1 What is Creativity?

Image and knowledge

First, we thought brain and counterpart outcome mentioned in Fig. 1. These words are enumerated as a similar manner. For example, we thought the image of some animal such as a cow (Fig. 2). Various and independent images to it are floated in the brain. On the counterpart, the letters and words such as cow are considered to be objective image of knowledge. Knowledge of cow is defined specific animal at least and goes to be common. Individual image goes to the image accompanying similarity and common in the progress of level. The high level of image reaches knowledge and a combination of knowledge. Subjective images are converted to objective image with clear definition.

Knowledge as a higher level of image is categorized as like those of three levels as shown in Fig. 3, i.e. the first as concept, the second as descriptive knowledge, and the third level as procedural one. From another standpoint, actual knowledge and potential one are there.

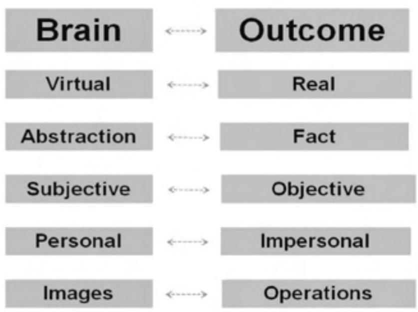


Fig. 1 Brain and counterpart outcome

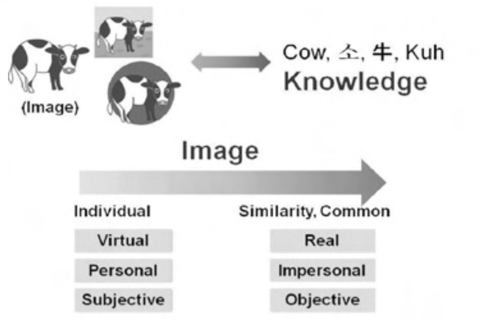


Fig. 2 Image toward knowledge

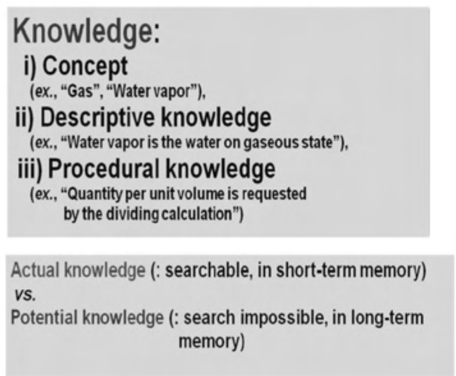


Fig. 3 Knowledge

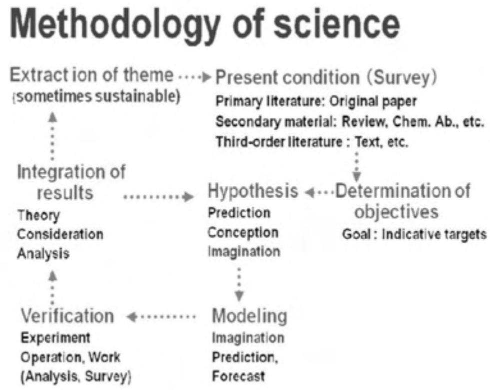


Fig. 4 Methodology of science

Problem-solving as methodology of science

One typical methodology of science represented in Fig. 4. The first, theme of research is extracted and the next, survey of present condition concerning the theme, determination of objective, hypothesis, modeling, verification, and integration of result are subsequently followed. Sometime reaches to be goal of achievement of theme. Normally, some specific steps are repeated from a certain result and sometime prolonged. In all processes imagination plays very important role, particularly in these processes of hypothesis and modeling. Knowledge and skills are also sufficiently exploited in all processes, of course. (Scientists, as much as any other profession, are passionate and involved humans whose work relies on inspiration and imagination as mentioned by Osborne [4].) Even in science education it is more desirable that students should educate themselves in a similar manner.

The process of problem-solving in science education is matched to the methodology of science in which creative thinking by use of knowledge is made good use. It makes a start on information-processing toward problem-solving in the process of creative thinking by use of knowledge. From the standpoint of relationship with knowledge in problem-solving, problem-solving pattern is categorized in three levels where Ⅰ) answer from views using actual knowledge such as "What is the physical quantity appropriate to show heat?", Ⅱ) answer by leverage using actual and potential knowledge such as "Why is calorific value appropriate to show heat?", and Ⅲ) answer by creative thinking requested conception (new ideas) accompanied with the creation of new knowledge structures such as "Which physical quantity is the best candidate to show heat exothermal?" are therein. The higher level becomes the more advanced and creative. Creative thinking has a strong relationship with problem-solving.

Creative thinking toward creation

Creative thinking would be defined two phases, where i) thinking toward creation of new knowledge by the combination of existing knowledge and ii) thinking toward creation of new appropriateness and/or new view to existing knowledge are nominated. These creative thinking are done the backup from interdisciplinary standpoint with four items of i) motive and wills toward creation, ii) aiming power of appropriateness to issues of events, ii)

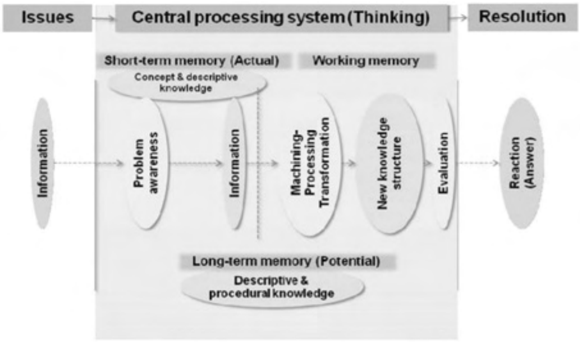


Fig. 5 Information processing scheme

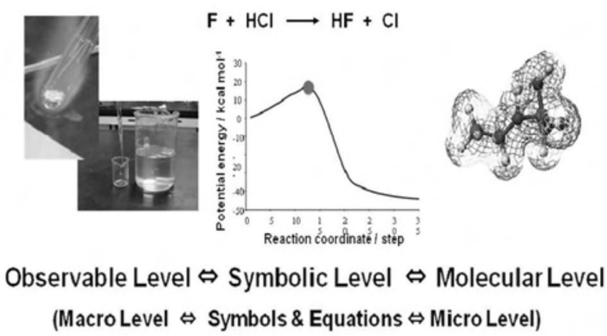


Fig. 6 Dividing the image into the three thinking levels

thinking by operation of knowledge, and iv) power to find out and determine the value. As a whole, we integrate and come out with the information processing scheme as shown in Fig. 5. Zone of pale red color means the inside of the brain. Once some issue comes in the brain, central processing system (thinking) starts to work in the brain, where information enters the brain and fixed as issues reflecting the interactions with concept and descriptive knowledge in short-term memory (actual knowledge) and descriptive and procedural knowledge in long-term memory (Potential knowledge). After that, the issue is subjected to such machining-processing and transformation, and then new knowledge structure is constructed and evaluated. Finally resolution comes out accompanying some reactions. Knowledge based on images works in all processes and plays very important role in the central processing system toward creative thinking lead to creation. Consequently, imagination would boost creativity.

2.2 What is SEIC?

SEIC policy

The learning on the basis of students' enthusiastic activities on imaginative thinking and behaving would be of great importance to understand science. Student's attitude being enthusiastic toward the possibilities of their own abilities with their own images would enhance the understanding of objectives. This approach of SEIC is expected that affluent images can enhance to foster creative thinking led to creativity through making good use of thought, ability for expression, and reason. Having imagination is emphasized with the hope of acquiring sufficient knowledge and skills toward promoting creativity in this SEIC program. The strength of will for imagination and creation will be raised. SEIC has the feature of student-initiative-activities such as brain-storming and student own activity, if need be, with teacher's support. The lesson puts a special emphasis on enhancing the imagination connected with creativity. The lesson proceeds properly by taking advantage of experiment, drawing, and CG based on quantum chemical calculation at appropriate stage of the lesson on the three thinking levels of observable level, symbolic level, and molecular level, respectively (Fig. 6). Dividing the lecture stage into the three thinking levels was mentioned by Tasker *et al* [13]. Visualization as a key of representation of images is great help for student to have images of phenomena, chemical concepts, and molecular world, and then the visualization enables student to realize images of them. Students' enthusiastic activities with imaginative thinking and behaving are expected in this SEIC program.

Lesson models

Fifteen themes were selected for the lessons in chemistry (for teaching profession in primary school) to an undergraduate university student. Fundamental contents on the topics were chosen on the basis of basic chemistry; i.e. the chemistry is roughly composed of three frames of structure, equilibrium, and change. Fifteen lessons in the model covered them moderately. Above all, three lessons from lesson 4 to lesson 6 include fundamental concepts in chemistry, i.e. stoichiometry, free energy, and entropy from the standpoint of rust of iron. The lessons proceed toward the theme of topics, i.e., the lesson 4, 5, and 6 proceed toward the themes of stoichiometry, activating complex, and entropy change of chemical reaction of rust of iron, respectively.

The lesson is typically divided in five activities. For example as 90-minute lesson, even in a lecture in about 45 minutes frequent discussions is performed with no students' memorization, and afterwards students' own memorization and collection of their thoughts in 10 minutes are carried out. Students' activities of drawings toward making images of chemical concepts and phenomena, and self-explanation should be performed in 15 and 10 minutes, respectively.

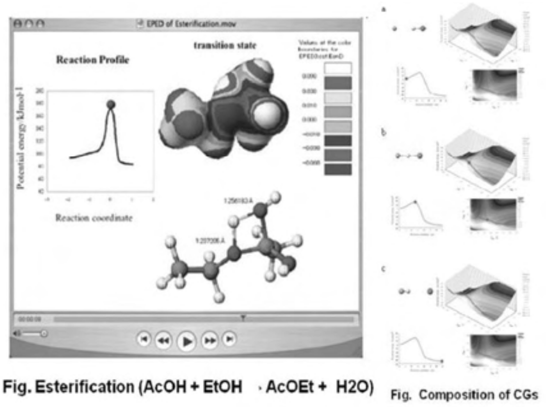


Fig. 7 CG graphics

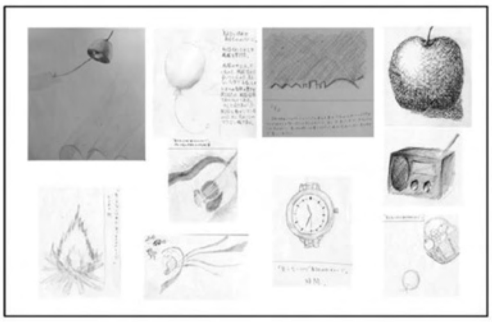


Fig. 8 Being but unseen (Lesson 1)

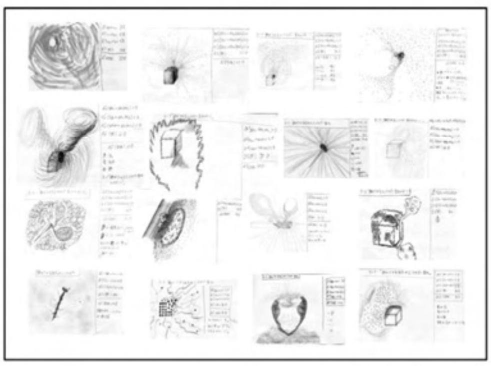


Fig. 9 Entropy: exothermic; rust of iron (Lesson 6)

Visualization toward images

Visualization is a key for student to have images of phenomena, chemical concepts, and molecular world, in which drawing, experiment, and CG based on quantum chemical calculation are taken advantage of properly at appropriate stage of the lesson on the three thinking levels of observable level, symbolic level, and molecular level, respectively. Realizing images led to understanding are expected to be enhanced with the hope of students' enthusiastic activities on imaginative thinking and behaving. CG graphic as a teaching material (Fig. 7) and students' drawings in the lesson (Fig. 8, 9) are raised as an example. Drawing is imposed on the students in the lesson as one of chief activity, where drawing rules are set as following; drawings should be attractive for everybody to see once again. Prohibition on drawing is regulated, e.g., description of text, mark, line, arrow, and illustration with simile in a drawing area. Explanations by text style were also available outside the drawing area in a sheet using chemical terms by solid-parting line.

2.3 Discussion

Scientists, as much as any other profession, are passionate and involved humans whose work relies on inspiration and imagination as mentioned by Osborne [4]. Even in science education it is more desirable that students should educate themselves in a similar manner. Thinking and behaving imaginatively in science would be important to promote creativity as outcome with value to the original objective [1, 2, 8, 14]. Child and/or Osborne, *et al.* mentioned that students should appreciate that science is an activity that involves creativity and imagination as much as many other human activities, and that some scientific ideas are enormous intellectual achievements [3, 4]. Visualization is a key for students to have images of objectives as in phenomena, chemical concepts, and molecular world. Students will have the images of the three thinking levels of observable level, symbolic level, and molecular level. Visualization at an appropriate stage of Experiment, drawing, Explanation, and CG based molecular world on quantum chemical calculation would be effective methods for those achievement. Realizing images led to understanding are expected to be enhanced with the hope of students' enthusiastic activities on imaginative thinking and behaving. Having imagination would be moreover emphasized with the hope of acquiring sufficient knowledge and skills toward promoting creativity. The learning on the basis of students' enthusiastic activities on imaginative thinking and behaving would be of great importance to understand science on the three thinking levels. Student's attitude being enthusiastic toward the possibilities of their own abilities with their own images would enhance the understanding of objectives. A further development of teaching materials is sincerely expected.

3. Lesson Model Toward Promoting Students' Creativity

The promotion of students' creativity is one of the recent research concerns in science education. For instance, School Science Review, a main magazine of Britain, made a special issue: "Creativity in Science" in 2009 [1, 5, 6, 7 and etc.]. Moreover, Revised Course of Study of high school science in Japan was announced in 2009, where the new subject of "Research Project of Science" was established in order to cultivate a base of students' creativity [15]. However, the research of this field in the high school chemistry develops up to now, and therefore neither proper contents of lesson nor effective teaching and learning methods to the promotion of creativity is shown.

On the other hand, the iron as the topic of this study is an important material widespread to our life. Many of machines, buildings, and living goods are made of iron. And then, a large amount of natural resources and energy such as iron ore, coal, water and etc. are needed for the production of iron. Therefore, we can understand the utilization of materials in today's life and society by paying attention to iron and consider a direction of the development and the utilization of materials in the future.

A lesson model of high school chemistry on the topic of iron is proposed herein, which is aimed at promoting student's creativity. An assumption which would influence the acquired knowledge and the judgment ability concerning feature of iron toward the creativity related to utilizations of iron is examined through this study.

3.1 Development of Lesson Model

The aim of making a lesson model is to promote the student's creativity based on knowledge and judgment ability concerning feature of iron. Contents of the lesson are composed of the following items:

- Lecture (120 min.): "Iron: raw material, manufacturing, utilization, and the history";
- Experiment (120 min.): "Metal plating on iron sheet and corrosion-protection by plating on iron sheet";
- Study Tour (half day): "Steelworks";
- Activity (180 min.): "Gathering information of iron and other materials for automobile by the Internet web sites", "Evaluation about utilization of iron and other materials for automobile."

A manual for the lecture, work-sheets for the experiment, and evaluation-sheets for the activity were made and exploited.

3.2 Trial of Lesson Model

The lesson model was carried out with 36 Japanese students (Hiroshima University High School) and 30 Korean students (Cheonan Jungang High School) of the 11^{th} grade during two days on January 12^{th} through 13^{th}, 2011. The 22 science questions selected from TIMSS were conducted with the students before the lesson in advance. When the score rate average of Japanese and Korean students was calculated, t-test was given to the average with p-value of 0.165 point ($p>0.1$). There was not necessarily significant difference in the academic achievement among both of students. Therefore, the students were of a proper research object for the approval of this comparative study.

Fig. 10 Metal (Tin, Zinc and Nickel) plating on iron sheet

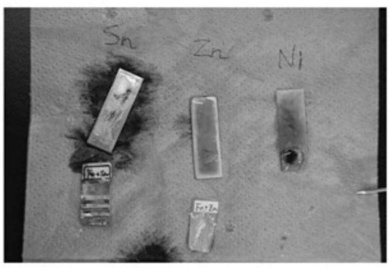


Fig. 11 Corrosion protection of plated iron

The first day; lecture and study tour in the lesson were carried out. First of all, the lecture on "What kinds of materials is an automobile made from" was performed in order to attract students' interest on the topic of iron. Then the lecture about (1) raw material of iron, (2) manufacturing of iron: the actual manufacturing process and that regarding to saving of energy and reducing of carbon dioxide, (3) utilization of iron: type of use, alloy, protection against corrosion, and recycling of iron, and (4) history of iron. In a part of the content (2), reduction of iron oxide with hydrogen instead of coke was demonstrated as a teacher experiment. In the study tour, a steelworks in the suburb of Hiroshima city was inspected and information about iron was gathered.

The second day; experiment and activity in the lesson were conducted. The experiment of the metal plating (tin, zinc and nickel) on iron sheet was done (Fig. 10). Then the corrosion- protection by plating on iron sheet was tested with potassium ferrocyanide solution by comparing color changes under the conditions of scratching with the tip of a nail and dropping sodium chloride solution (Fig. 11). In the activity, information about iron and other materials for automobile components was collected by Internet web sites. Then possibilities of utilization of iron and other materials were discussed as a group activity, and then models of future automobile made from prospective materials were creatively sketched as an individual activity.

3.3 Evaluation of Lesson Model

In the case of related terms of iron enumerated by the students, the knowledge about physical properties of iron remarkably increased in number among both of the students after the lesson. The number per a student was about 1.9 times large in Japanese students and 2.5 times many in Korean students. The knowledge was those referred to as connecting category of knowledge and forming networks of knowledge (Fig. 12).

Regarding the assessed materials (steel, aluminum alloy, and synthetic resin) from the standpoint of utilization for the body of automobile, about 43% and 32% of assessment criteria enumerated by Japanese students and Korean students, respectively, were those related to physical property of materials (specific gravity, strength, hardness, durability, and forming, etc.) (Question 1 in Fig. 13) [16]. Then performance value of the assessment which were allocated by the students displayed their judgment based on acquired knowledge concerning physical properties and other features (price and recycling, etc.) of materials (Question 3 in Fig. 13).

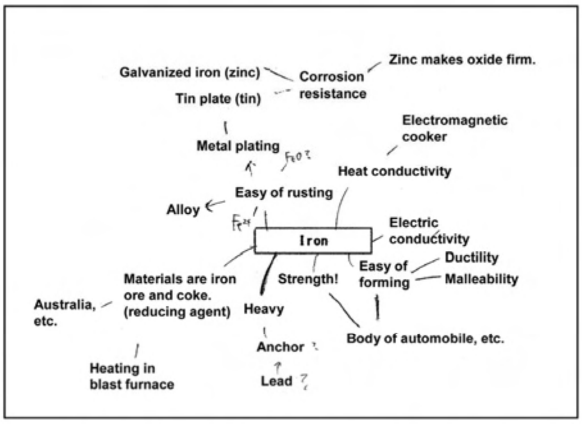
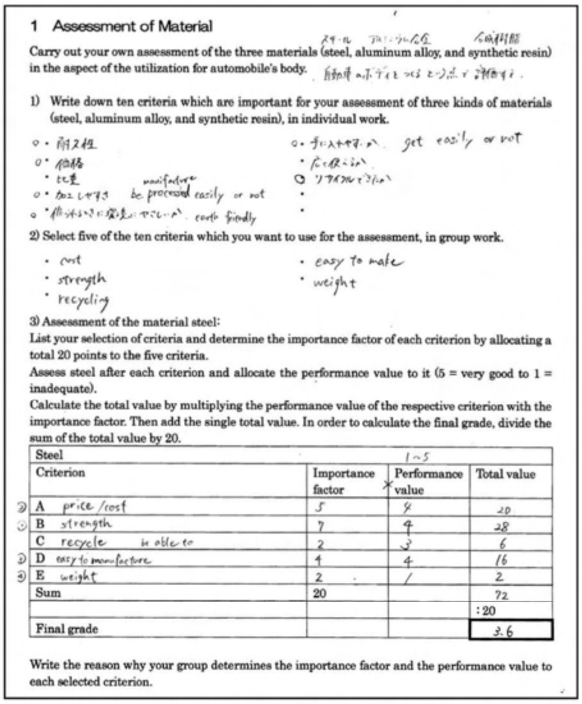


Fig. 12 Acquisition of knowledge about physical properties of iron (after the lesson)



1 Assessment of Material

Carry out your own assessment of the three materials (steel, aluminum alloy, and synthetic resin) in the aspect of the utilization for automobile's body.

1) Write down ten criteria which are important for your assessment of three kinds of materials (steel, aluminum alloy, and synthetic resin), in individual work.

- 耐久性
- 価格
- 比重
- be processed easily or not
- earth friendly
- get easily or not

2) Select five of the ten criteria which you want to use for the assessment, in group work.

- cost
- strength
- recycling
- easy to make
- weight

3) Assessment of the material steel:

List your selection of criteria and determine the importance factor of each criterion by allocating a total 20 points to the five criteria.

Assess steel after each criterion and allocate the performance value to it (5 = very good to 1 = inadequate).

Calculate the total value by multiplying the performance value of the respective criterion with the importance factor. Then add the single total value. In order to calculate the final grade, divide the sum of the total value by 20.

Steel		1~5	
Criterion	Importance factor	Performance value	Total value
A price /cost	5	4	20
B strength	7	4	28
C recycle be able to	2	3	6
D easy to manufacture	4	4	16
E weight	2	1	2
Sum	20		72
			:20
Final grade			3.6

Write the reason why your group determines the importance factor and the performance value to each selected criterion.

Fig. 13 Work-sheet to assess materials of automobile (Omission about assessment of aluminum alloy and synthetic resin in Question 3))

In the case of selected materials used for some parts of future automobile with rough sketch, some students showed creative representations including originality, practicality, sensibility, and/or inclusiveness [2 on p.37-43]. These representations were based on the judgment to the value of materials from the points of features including physical property while the representations were or not those reflected knowledge about materials (Fig. 14: a creative representation including originality. In the student's assessment of materials, final grade of synthetic resin is higher as well as that of steel.).

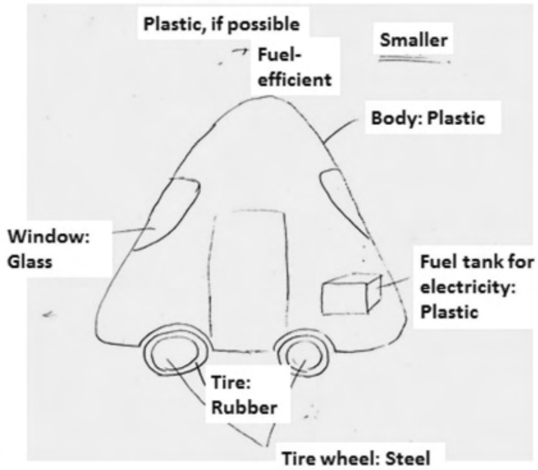


Fig. 14 Materials of some parts of future automobile

3.4 Closing

According to Finke *et al.* [2 on p.89], the restriction of imagination on the task, which is given to objective person, is an important factor for promoting their creativity. This was supported by the result of this study. Indeed, the students who clearly understood the restriction on the task of "future automobile" imaged solar car, electric vehicle, or fuel-cell car, and selected suitable materials for these automobiles. Then the students who focused on body and frame along another restriction on the task of "parts of automobile" deeply considered materials of the parts. Our further research would be to investigate setting of the task for promoting students' creativity. Moreover, a significant relation between students' creativity and judgment ability related to features of materials including iron was found by this study while the relation between students' creativity and acquired knowledge was not made clear through the survey in this time. Some modify of the survey would be needed in the further research.

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- Invited Workshop 2
- Date: Wednesday, October 26, 2011
- Time: 15:20 ~ 16:20
- Room: #2 (1F)
- Chair: Yong Jae Joung (Gongju National University of Education, Korea)

SMALL INTERVENTION: BIG CHANGES? CHANGING PRE-SERVICE TEACHERS IDEAS ABOUT FORCES

Steven Chapman
University of London, UK

Abstract

In the UK science graduates follow a nine-month post-graduate course to become a science teacher. While physics and engineering graduates teach beyond age 14, biology and chemistry graduates teach also physics from 11 - 14. How can these pre-service teachers improve their knowledge of forces when faced only such a short session? How can those sessions serve the needs of both specialist physics teachers with deep but narrow knowledge of physics and non-specialists lacking physics knowledge? The paper outlines both the approach taken and evaluation using detailed analysis of diagnostic questions of its success. In particular there is a successful transition from an Aristotelian to a Galilean paradigm when thinking about forces and motion.

Problem

In the UK to become a secondary science teacher graduates in biology, chemistry and physics do a one-year (actually none-months) postgraduate course called a Post Graduate Certificate of Education (PGCE). All have to teach biology, chemistry and Physics from 11 to 14 and many biologists and chemists have to teach physics up to 16 (IOP 2010, SCORE 2011). There is a shortage of graduate physics teachers in the UK, as there is in many other countries. Although the non-specialists lack physics knowledge they do often have a strong background in broad science and have very good degrees from prestigious higher education institutions. Whilst they can read about the physics subject knowledge they will not be able do the same for suitable pedagogy and hinterland knowledge, for example historical anecdotes or models,

On the PGCE course PSTs spend two-thirds of their time in schools where there are very few physics teachers, (particularly in large cities like London, Birmingham or Manchester). This means it is very difficult for them to improve their knowledge in schools (STAT about number of physics teachers). This leaves us with two large problems:

Problem 1: How can we help the biologists and chemists teach physics?

Problem 2: The physicists have very deep but narrow knowledge of physics. However this knowledge is not necessarily robust enough for the very challenging task of explaining something to an eleven year old. Then there is the related problem of confusing understanding physics with solving equations.

Working with Physics Graduates

Here is a sample physics question (EdExcel PSA6 Sample 2007):

> (d) Use the equation $mv = e\varphi/2\pi r_0$ to find the unit for magnetic flux in terms of base units. Show that your unit is consistent with the magnetic flux density B being measured in N $A^{-1}m^{-1}$

Here's what the student actually sees:

> (d) Bla fgh sdruantmn $mv = e\varphi/2\pi r_0$ fr fgyd bvr ftwm jyw fgtenetif drju fr druwn dw drig unjytw. dfyi aprq fkri flpp is dplnwrthynt cvdt feg fgtenetif lhrw deshgj B rtyui wertgfds ht N $A^{-1}m^{-1}$

In order to measure the effectiveness of what we were doing we decided to try and capture whether what we were doing was successful in particular we wanted to probe the impact of focused professional development courses on teachers' understanding of specific scientific concepts and associated pedagogical Knowledge and to examine any impact of the teachers' enhanced skills/knowledge, post intervention, on students' learning of specific scientific concepts. This work builds on a number of earlier projects and the same test instrument had been used by colleagues at the University of Leeds on teachers attending Continuing Professional Development courses for experienced, but non-specialist Physics teachers (Scott *et al*., 2010). This included courses I had run and we decided in order to compare the data sets between the PST cohort and more experienced teachers we should use the same diagnostic instrument.

Background

Each PST, in a cohort of approximately 100, (45, Biology, 30 Chemistry and 25 Physics) took part in Subject Scaffolding a series of three-hour physics sessions:

- Forces and Universe
- Light and Sound
- Energy and Electricity

Each one is highly practical, and much material is provided at the point of need by the Institute of Physics' *Supporting Physics Teaching* (SPT) (see IOP (2006)) but for each one there is a key set of ideas for the class to tackle. In particular the SPT material provided the bulk of the Physics narrative and teaching approaches. The sessions concentrated on major misconceptions (Driver, Wood-Robinson *et al*., 1994, NCC 1992) or analysing the effectiveness of models and also giving student teachers the chance to use the kind of practical equipment available in all schools (Kibble 2006).

For the Forces and Universe session our strategy was to tackle key misconceptions head on and we were looking for a shift in their thinking from an Aristotelian to a Galilean viewpoint. This mainly relates to both pupils' and student teachers' penchant for thinking an object forward movement has a corresponding force pushing it forward.

The Sessions

The Forces Sessions covered the following Big Areas:

- *What is a force?*
- *What can it do?*
- *More than one force?*
- *Forces come in pairs?*
- *Newton's Laws?*
- *Floating and Sinking?*

However the key was starting with Pupils' Ideas about Forces. This was our way of gaining our first insight into our student teachers' ideas about forces. A number of videos had been recorded for the SPT materials being asked to explain scenarios. For example a cup is placed on a table and two pupils are asked to talk about all of the forces acting on it. This provided us with an opportunity for a Trojan Horse approach to access our PSTs understanding. We asked the PSTs to guess what the two pupils would say. This gave real insight into the PSTs ideas without threatening the fragile confidence of the non-specialist teachers and allowing the specialist ones to expose their own over-confidence too. This was also coupled with pupils' work from primary schools (in England and Wales children study science from age 4) to show the kind of work they had encountered before. The key ideas we wanted them to grasp being pupils have everyday experiences of contact forces and pupils have little experience of action at a distance forces like gravity or electrostatics.

The sessions then moved onto simple force diagram activities based around a circus taken from the Nuffield Practical Physics website (www.practicalphysics.org).

The idea of Force Spectacles; taken from the SPT materials, was crucial: Scientists look at the world in a different way- they isolate objects and look at the forces on that object. They assign arrows to show the size and direction of the forces.

The arrows need to be anchored in the object you have chosen. The arrows represent (a model) of forces, and arrows should only be used to represent forces, not for example to show movement.

Before each session each PST was given a short test and then 1 month later the same test was repeated, a smaller number took the test six to nine months later. This number was reduced as the teachers were now in schools as practising professionals.

The two key questions relate to a skater (a) and to a ball being thrown in the air (b). These were key because they both addressed the Galilean switch we were looking for. However experience of running the sessions over many years guided us into thinking that a new context often fooled PSTs into producing their phantom new force.

SPT Impact IoE 2010

3. Skater

You are planning a lesson about forces. In the science staffroom you find an old diagram showing a skater gliding across an ice rink. The skater has just pushed-off and is very gradually slowly down.

a. On the picture above show how you would draw the *forces* acting on the skater when using the diagram in the classroom.

Angelina, one of your pupils, says:

'As long as the skater is moving forwards there must be a force pulling her - that's for certain!'

b. How would you respond to Angelina?

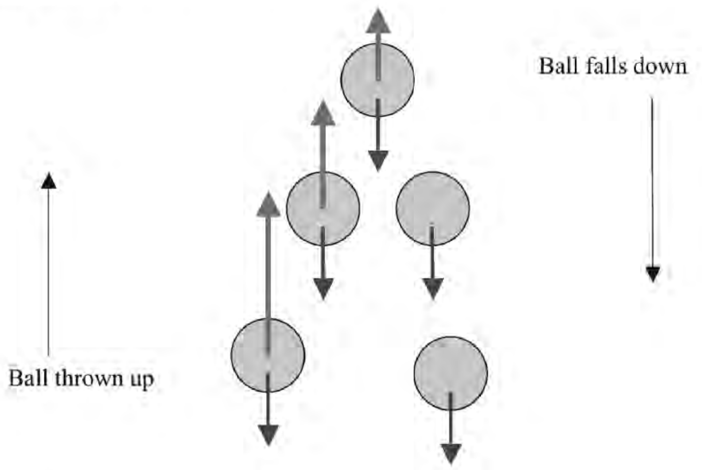
Response to Angelina:

1

SPT Impact IoE 2010

4. Ball in the air

You are teaching forces and motion to a bright Year 8 class. One of the pupils, Troy, argues that the forces acting on a ball, when it is thrown **straight up** in the air, are as follows (the diagram shows the ball after it has been thrown).



Troy says:

'When you throw the ball up, it sets off with a BIG upward force (this one pointing up) but this gradually runs out and gets less, so that at the top the upward force is balanced by gravity and the ball stops going up. The ball then falls because of the pull of gravity'.

a. Do you think that Troy is correct in what he says?___________[YES/NO]

b. What would you (the teacher) say in reply to Troy?

2

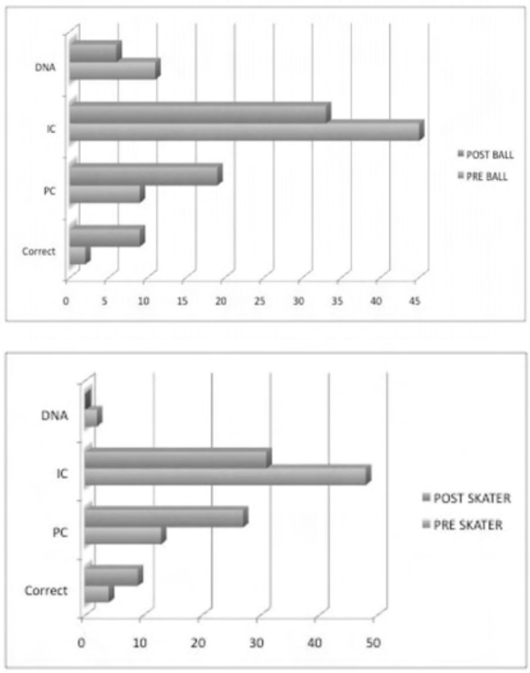


Figure 1 Skater Pre and Post

Result

Pre Test

Firstly the standard of the PSTs' initial subject knowledge was very low, whatever their specialism. This result is surprising, as many of the PSTs had just graduated (within three years) from some of the UK's most prestigious Universities. Many had done basic physics as part of broader subjects like Natural Science. The physicists' results were not significantly better than the biologists' and chemists'. Many PSTs gave the skater a forward force even though she is clearly gliding, many ignored up and down forces and many talked about energy.

Post Test

Firstly the standard of the PSTs' subject knowledge was very much better, but not as good as the experienced teachers after the CPD courses. The forward force was removed in many cases for the skater but re-appeared as an upward force in the ball question. However there was improvement as the graphs show.

There were however some hard-core cases beyond redemption. One biology student put in their post test:

Q: What would you say to Troy?

A: *Well done Troy.*

So clearly more work is needed in some cases.

After 6 months this knowledge was still good but had declined, but we only have 25 results for the post- graduation results, however the amount of physics teaching involved seems to lie at the heart of the matter.

What is clear though is that even a short intervention seems to make a tremendous difference to the subject knowledge of the students. This is, we hope, because we have induced a change in their thinking, so that the key idea of force and motion not being interchangeable has been drilled in. This is possible in physics we feel, because the epistemology of ideas in physics is very different to other sciences, like biology for example. There are a few key ideas that can underpin work from lower secondary school right up until undergraduate level. Inducing a paradigm shift in thinking then, is more achievable in a short time.

The biggest change as a result of the sessions, as noted by fellow tutors, was an acknowledgement of PSTs' lack of knowledge and an insight into how little they actually knew. As one PST (a physics graduate) wrote in his MA assignment.

The move from learning degree level physics, to teaching the fundamental principles of physics meant making the transition from thinking I understood physics, to ensuring I didn't misunderstand it.

Next Steps

This work is ongoing and successive cohorts will be tested on their knowledge both for action research purposes and for research. The SPT materials are being modified for use with primary teachers.

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www.practicalphysics.org

E·A·S·E

- Contributed Workshop 1
- Date: Wednesday, October 26, 2011
- Time: 15:20 ~ 16:20
- Room: #3 (1F)
- Chair: Chi-Jui Lien (National Taipei University of Education, Taiwan)

1.

SCIENCE EDUCATION CONTENT STANDARDS FOR NATIONAL K-12 SCIENCE CURRICULUM IN KOREA

Yoon-Su Baek
Yonsei University, Korea
HyunJu Park
Chosun University, Korea
Jin-soo Jeong
Daegu University, Korea
Eunjeong Yoo
Shinsa Middle School, Korea
Jongwon Park
Chonnam National University, Korea
Sukgoo Loh
Gyeongin Unversity of Education, Korea
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KOFAC, Korea

Science education content standards have not been suggested until now in Korea. There were no demanding needs since Korea has a national k-12 curriculum. However, as schools and societies change into diverse systems, diversity in school education is also required and national curriculums are modified continuously to respond. Since schools and education offices in local districts can develop or choose a diverse curriculum based on the national curriculum, a new way of guidance such as science education content standards have become necessary in science education. We tried to suggest the idea of science education content standards, describing how science education content standards in Korea would look. In our suggestion, content includes knowledge, inquiry, nature of science, and creativity in science. Also, we suggested a spectrum of situations which describes how science works in our life and human world. At the end of the spectrum, there is everyday life that science works. At the other end of the spectrum, there is professional scientific research. In this way, we would like to introduce students how science works diversely in human world. Further, we tried to relate science and engineering hoping to provide insights for STEM education. In this workshop, we wish to introduce our idea and how we would implement it step by step. In each step, we would like to discuss how to improve idea with participants. Finally, we hope to suggest positive implication for developing science education standards in the future.

- Contributed Workshop 2
- Date: Wednesday, October 26, 2011
- Time: 15:20 ~ 16:20
- Room: #4 (2F)
- Chair: Mariko Suzuki (Shiga University, Japan)

2.

DEVELOPMENT OF INSTRUCTION MODULES OF MOLECULAR BIOLOGY EXPERIMENT FOR HIGH SCHOOL STUDENTS USING THE DNA OF HUMAN ORAL CAVITY EPITHELIAL CELLS

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On the corresponding with current development of molecular biology, laboratory-based molecular biology instruction modules were developed for high school students to improve concepts related to DNA. The modules have successive 6 steps which contain a DNA extraction procedure of human cavity epithelial cells, a DNA gel electrophoresis to confirm genomic DNA, using bioinformatic databases to get informations of specific genes for PCR, a PCR treatment of a specific gene, the observation of a specific gene by DNA gel electrophoresis, a treatment of a restriction enzyme to cut a DNA site of a specific gene, and the observation of a single nucleotide polymorphism to learn DNA variation. These modules were developed understand not only molecular biology concepts but also molecular biology experiment tools and equipments using the concepts. To get the effect of these modules, we applied them to 75, biology extension classes of 12th grade students, and 24, after school classes of 10th and 11th grade students of a high school located in Seoul and analyzed students' responses through questionnaires which were put right after instructions. We got results that the modules are adjustable for high schools from the students' responses of the understanding on modules. Also students responded that their understandings on the relations of DNA, gene, and protein got much easier through these modules and their attentions and interests on molecular biology news shown on TV, computers or newspapers were also increased. For 10th and 11th grade students, the instruction modules influenced students' minds on selections for the biology major and career course. The understanding of the developed instruction modules had meaningful relations with students' subject scores($p<.01$ or $p<.05$). These modules could be properly reconstructed according to the level of students or laboratory environments. And they also do for teachers training course programs.

As for the 2011 EASE workshop program, the 6th experiment module will be introduced. The 6th module was developed to learn the concepts on SNP(Single Nucleotide Polymorphism) which explains how different DNA base sequences by persons. After a treatment of an appropriate restriction enzyme to the specific SNP site of DNA samples, some are cut at the specific SNP site who have SNP and the others are not because of no SNP site. Through DNA gel electrophoresis during the workshop, we can distinguish RFLP(Restriction Fragments Length Polymorphism) of sample DNAs and experience DNA fingerprinting process which have shown often on TV or internet etc.

- Contributed Workshop 3
- Date: Wednesday, October 26, 2011
- Time: 15:20 ~ 16:20
- Room: #5 (2F)

3.

COMPUTER-BASED PHYSICS LABORATORY: USE OF MOVING PICTURE SYSTEM

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Segye Scientific Co. is a company which develops and manufactures laboratory equipment for physics teaching and learning. In this workshop, we introduce Segye moving picture system which is a computer interface device collecting and analyzing data. This system supports various physics labs such as air track experiment, simple pendulum, free-fall and projectile motion, measure of centripetal force and rotational inertia, etc. We provide opportunities for the workshop participants to use this moving picture system; i.e. how to collect and analyze data using a camera of moving picture system. We also present some optics demonstrations using new devices of Segye Scientific Co.

E·A·S·E

- Science Demonstration 1-A
- Date: Wednesday, October 26, 2011
- Time: 14:20 ~ 15:20
- Room: Main Room

1. SD1-A1

ELECTROLYSIS AND FUEL CELL

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Fuel cells generate direct current by converting chemical energy to electric energy. During the process, fuel and air are continuously supplied into the cells. In the fuel cells, hydrogen and oxygen gases are supplied to anode and cathode, respectively where they react with electrolyte to generate ions, Electrons are generated at the anode (fuel) and move to cathode(air) to generate electricity. In this experiments, we want to electrolysis water to generate hydrogen and oxygen gases and used them as fuels to generate fuel cell electricity.

2. SD1-A2

OXIDATION AND REDUCTION OF COPPER

YoungChoul Park*
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A piece of copper is supported over a burner and is heated. The copper begins to react more rapidly with oxygen from the air and a darker color can be seen on the surface of the copper. This is similar to the color that forms on copper cookware when it is used in a kitchen. A few seconds later the copper has become dark. It has reacted with oxygen in the air. The burner flame is turned out and an inverted funnel with hydrogen gas blowing out of it is placed over the copper. The hydrogen gas is a reducing agent. It reduces the copper oxide on the surface of the copper and causes pure copper to be formed again. The dark color disappears leaving a pure copper color. Oxidation and reduction of the copper can be repeated several times by removing and replacing the funnel until the metal cools and the reactions slow down.

3. SD1-A3

MOLAR VOLUME OF A GAS

Eugene Wee*
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The purpose of this lab is to determine the molar volume of a sample of Hydrogen gas that is created through the reaction of Magnesium and Hydrochloric Acid. The concept of molar volume is that 1 mole of a gas occupies 22.4 liters at STP. Unfortunately the conditions of the lab are not at STP. You will have to use gas law formulas to calculate the volume that one mole of this gas would occupy at STP. In addition, since this lab is being done over water, and water will evaporate at any temperature, the vapor pressure of water must be determined. This is not a calculated value but is looked up on a chart. In order to obtain the pressure of the 'dry' gas, you will have to use Dalton's Law of Partial pressures. There is a lot of chemistry going on in this lab. You need to pay attention to and concentrate on what you are doing.

4. SD1-A4

THE GENERATION OF CHLORINE, THE REACTION

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Halogen elements are found in the periodic table in group 17, comprising F(fluorine). Cl(chlorine), Br(bromine), I(iodine). The halogen elements are highly reactive, so they are hardly found in the form of isolated atoms. The halogens are found in many kinds of compounds and also they are used in various fields. Usually, halogens are stable in forms of diatomic molecules such as F_2, Cl_2, Br_2, and I_2. Due to the same electron configuration in the valence shell (ns2np5), the chemical properties and reactivity of the halogens become similar. All halogens have 7 electrons in their valence shells, and consequently, they tend to get 1 more electron to be stable.

$X + e^- \rightarrow X^-$ (X means halogens such as F, Cl, Br, I).

In this experiment, we demonstrate the method for the production of chlorine gas in the laboratory. Also, we compare the relative reactivities of F(fluorine). Cl(chlorine), Br(bromine), and I(iodine) using a few simple reactions. Finally, the various properties of chlorine gas are investigated.

5. SD1-A5

IDENTIFICATION OF IONS BY USING UNIVERSAL INDICATOR

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Electrolysis uses electric current to cause chemical reactions. The process of electron lose and electron gain is occurred simultaneously. Electrolysis occurs in the solution containing cation and anion with two electrodes, cathode and anode. The material to be changed may be electrode or component of the solution, and may soluble in the solution. Electrons are moved from the cathode and positive electrolyte in the solution is moved to this electrode and changed to neutral element or molecule. Negative electrolyte in the solution is moved to anode and changed to neutral element or molecule. In the case that the electrode is changed, the electrode loses electron and dissolves into the solution. In this experiment, we identify the ions formed during electrolysis of water by using universal indicator.

6. SD1-A6

HYDROGEN GAS FORMATION EXPERIMENT

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This experiment is one where hydrogen is formed by the reaction between several pieces of metal and the two acid, acetic acid and hydrochloric acid. The experiment process is as followings: First, set the hydrogen formation device by using a 5 centimeter-long straw, a 3 centimeter-long glass tube, and 96-Well. Then, sample the formed hydrogen gas by using detergent, and identify it by flame. Moreover, compare the reactivity of magnesium, zinc, and iron by using them in the experiment. The strengths of acetic acid and hydrochloric acid are also be compared. The strong point of this experiment is that it is safe as small amount of metal and acid is used, and it is simple as a straw and a glass tube are used.

7. SD1-A7

THE PRINCIPLE OF CONVECTION

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If there is the temperature difference in a fluid, density of the hot spot gets smaller and rises, and the density of cold spot relatively gets larger and falls. This is called 'convection.' Put two temperature sensors inside a test tube; one at the top and the other at the bottom. After that, heat the bottom. Then you will see convection which is caused by temperature difference between the top and the bottom.

8. SD1-A8

HOW TO MAKE A COLOR ICE PACK

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1. If there is the temperature difference in a fluid, density of the hot spot gets smaller and rises, and the density of cold spot relatively gets larger and falls. This is called 'convection.' Put two temperature sensors inside a test tube; one at the top and the other at the bottom. After that, heat the bottom. Then you will see convection which is caused by temperature difference between the top and the bottom. 2. An indicator is a substance which tells whether a fluid is acid or alkaline. Using color changes of indicators, you can make rainbow ice packs. First, put urea in an ice pack, and then endothermic reaction happens and temperature decreases. Next, add a little of bleach cleaner(Sodium hypochlorite), vinegar, and indicators in the ice pack. In this way, You can get ice packs of various colors.

9. SD1-A9

THE EFFECT OF THE OPEN INQUIRY LEARNING ACTIVITIES ON PROBLEM SOLVING ABILITY, AND LEARNING ACHIEVEMENT

Penporn Wangpoomyai*, Tassance Bunterm
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To enhance problem solving ability and learning achievement for students by constructivism Through the thinking process and the learning activities, Open Inquiry Learning Approached and Conventional Learning. The purposes of this study were to compared means of problem solving ability, learning achievement, and study correlation between problem solving ability score, learning achievement score between students in two different contexts: Open Inquiry Learning Approached and Conventional Learning. The population was 130 Grade-10 students and a sample chosen by simple random sampling. The students were randomly organized into two groups : 42 students in the experimental group and 44 in the control group, by drawing numbers. For data gathering pretest – posttest by problem solving ability test, science achievements test, science process skill test, and scientific attitude scale. The collected were analyzed by means of computing percentage, standard deviation and a t-test. The finding : The pretest mean scores of the two groups 1) Problem solving ability, achievement, and science process skill were not different at the .05 level of significance, but scientific attitude were different at the .05 level of significance. Student's scientific attitude experimental group higher than control group. 2) Correlations were computed to the relationship experimental group means of achievement and problem solving ability were positive correlation at .05 level of significance, achievement and science process skill were positive correlation at .01 level of significance but achievement and scientific attitude were not significance at .05 level. Correlations were computed to the relationship control group means of achievement and science process skill were positive correlation at .05 level of significance but achievement and problem solving ability and scientific attitude were not significance at .01 level.

10. SD1-A10

PSYCHIC TRICKS?

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National Kaohsiung First University of Science and Technology, Taiwan

Have you ever seen a leaf shaking solely among leaves in a tree? How can it be explained by a reasonable reason of why? Because of wind ? of religion? of mysterious force ? There are three sticks with different length attached on a plate bar, what will happen on the each of sticks when the bar is shaken with different tempo of frequency? What does each of stick occur if the tempo is becoming quicker? What will be if the tempo changed slower? Why does it happen? Now, you will be given a stick suspended with three cords in different length, can you have one of them vibrated solely by using the eye contact while others pause ? Let's have a hands-on kit to explore the personal magic and potential force in your mind. After the hands-on experiment, we can realize and understand how the earthquake affect the different height of buildings, how the food is cooked by microwave oven, how to prevented the double wire device from being overturned, how to ensure the safety of crossing the suspending bridge.

- Science Demonstration 1-B
- Date: Wednesday, October 26, 2011
- Time: 14:20 ~ 15:20
- Room: Lobby

11. SD1-B1

TO OBSERVE RESONANCES WITH A DOUBLE PENDULUM

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The length of the pendulum corresponding to each line has their own unique frequency. Single bar installed in two different lengths of the pendulum, then forced by the vibration will. (Forced oscillations may be added to the external periodic force vibration system is what happens when you are vibrating.) Thus, when forced oscillation frequency of vibration applied from outside, and if that matches the resonance frequency by the energy is amplified. Therefore, the frequency corresponding to the length of the pendulum to the other forces imposed from the outside that gave the pendulum will move corresponding to the frequency.

12. SD1-B2

CONFIRMING STATIONARY WAVES THROUGH FLAMES

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We already know the principle of standing waves. However, students find it difficult to understand how the standing waves are made from strings and pipes so they want confirmation. Producing standing waves using strings and pipe flames can be used to show this dramatic process with very simple equipment. Also, the link of an instrumental performance with the flame's movement leaves a strong impression on students' view of standing waves.

13. SD1-B3

SIMPLE HYDRAULIC EQUIPMENT MADE BY ORDINARY STRAW AND PLASTIC BAG

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Usually, the Pascal's principle is applied to the machines like car lift, hydraulic press and so on. However, it is not easy to figure out how this principle is applied because we can't see the internal structure of them. So, this demonstration shows how the Pascal's principle works using two plastic injectors and how we makes a simple hydraulic equipment using a ordinary straw and a plastic bag. You will be able to see how powerful this simple equipment made of a straw and a plastic bag could be.

Source : Yoji Takikawa Professor(The University of Tokyo)

14. SD1-B4

COTTON COMBUSTION BY GAS ADIABATIC COMPRESSION IN AN AIRTIGHT CONTAINER

Jin-ho Choi*
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When gas is compressed adiabatically, energy can not be released and the gas temperature increases. As the air in a cylinder is compressed adiabatically, rising temperature, which is enough to burn cotton, can be expected. Through this demonstration, we can check internal elevated temperature of gas by adiabatic compression and predict the temperature using the [TV r-1 = const] formula.

E·A·S·E

- Oral Presentation 1-A
- Date: Wednesday, October 26, 2011
- Time: 16:40 ~ 18:20
- Room: #1 (1F)
- Chair: Yew-Jin Lee (Nanyang Technological University, Singapore)

1. 01-A1

INQUIRY-SCIENCE IN A STRAIGHTJACKET? : THE INTERPLAY OF PEOPLE, POLICIES, AND PLACE IN AN EAST-ASIAN DEVELOPMENTAL STATE

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While there is no dispute that inquiry-based approaches in science education are desirable curricula goals, past efforts at their implementation in classrooms have always been problematic. This is mainly because implementation processes confront many challenges and usually map imperfectly from developers' intentions to actual practice. Using data from a recent school-based inquiry-science curriculum in Singapore, we show how this program compromised its aims of making science relevant and enjoyable for children due to subtle tensions with other existing educational policies and sociocultural norms in the country and classroom. Specifically, our analysis shows how there were interacting levels that we group under people, polices, and place that can influence-both positively and negatively-the implementation processes and thus program success. Our study has important implications for science educators who merely focus on theoretical aspects of science curricula (e.g., ensuring a right or adequate amount of inquiry) but neglect the practical aspects of program implementation and understanding educational change as inevitable complex ecologies.

2. 01-A2

DEVELOPMENT AND THE EFFECTS OF NEW MEASUREMENT EXPERIMENTS FOR THE EARTH SIZE

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This study is to find the problems embedded in the measurement experiments for the earth size in the current curriculum, to develop a new measurement experiment for the earth size and to establish the effects of them. For this study, pre-service elementary teachers, who had experienced the experiment of measuring the size of the earth in middle school, were demanded to perform the experiments in the existing national curriculum, and their responses collected through in-depth interviews were examined. To begin with, the pre-service elementary teachers conducted the experiment of measuring the earth size, then recorded the problems while doing it, and at the end they were administered in-depth interviewed. Based on the problems enlightened, a new measurement experiment for the earth size was invented that was applied to the same subjects, and the effects were analyzed through the in-depth interviews. Protocols which were mutually categorized and analyzed by two researchers were obtained based on the records produced while conducting the experiment and in-depth interview data. The subjects mentioned that the experiments for measurements of the earth size in the current curriculum give rise to difficulties in precisely measuring the angles between the string and the post and there is a scientific contradiction that solar altitudes are increased in high latitude region. For this reason, an alternative experiment method was developed to measure the earth size using the distance difference of two places and the solar altitude difference. The subjects all agreed that the new experiment can acquire more precise measurements and it is easier, faster and consequently more effective than the existing methods. Through the results of this study, it is judged that the newly developed experiment by the researchers can overhaul the problems of the current experiments and be an effective alternative to the current experiment.

3. 01-A3

A STUDY OF CONSTRUCTING MULTIMEDIA TO ENHANCE SCIENCE LEARNING FOR 5TH GRADERS

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Ming-horng Lai
Wan-da Elementary School, Taiwan

The purpose of this study is to investigate how constructing multimedia affected students' science learning on the development of student's science content knowledge, logical thinking skills, problem solving skills, and interest in computers. There were 96 students at an elementary school in Taipei participated in 15 weeks of Scratch programming to design multimedia during their science learning. Three research instruments were used in this study include a logical thinking test (for pre- and post-test), a problem solving test (for pre- and post-test), and a learning questionnaire (for post-test only). The results were undergone by t-test analysis. The findings of this study include (1) the outcomes of the logical thinking test indicate that students did better on their post-test than pre-test ($t = 2.647$, $p < .01$); (2) the outcomes of the problem solving test indicate that students did better on their post-test than pre-test ($t = 4.504$, $p < .001$); (3) students' self reports show that they favored in creating multimedia during their science learning, and by doing so help them had a better understanding on science concepts, (4) feedbacks from the questionnaire also indicate that students were willing to do similar multimedia projects for other science units in the future. Therefore, it can be concluded that using Scratch in constructing multimedia did improve 5th graders in their science learning.

4. 01-A4

THE IMPACTS OF THE INQUIRY-BASED GENERAL CHEMISTRY LABORATORY USING THE READING FRAME-BASED SCIENCE WRITING HEURISTIC APPROACH ON COLLEGE STUDENTS' REFLECTIVE THINKING

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This study aimed to examine the effects of chemistry laboratory investigations using the reading frame-based Science Writing Heuristic(R-SWH) approach on college students' achievements in terms of the understanding of chemistry concepts, critical thinking, academic achievement and the science summary writing. This study also examined the impact of R-SWH Approach on students' reflective thinking. Participants of this study were thirty three sophomore students majoring in science education at a National University in Korea. The SWH approach was implemented for sixteen students enrolled in one cohort and traditional general chemistry laboratory activities were implemented for seventeen students enrolled in the other cohort. There are three independent variables in this study: SWH approach, whether reading frame was provided or not in SWH approach and learner's level of metacognition. According to the level of metacognition in pre-test, experimental group was further divided into two sub-categories: high level metacognition group and low level of metacognition group, each consisting of eight students. After that, eight students of each level of metacognition was divided whether the reading frame was provided or not, each of which had four members in SWH approach. In short, Participants of this study were grouped into three groups: Reading frame-based Science Writing Heuristic (R-SWH) group, Science Writing Heuristic(SWH) group and traditional experiment group. Results of this study indicated that: First, there was significant difference in both groups' chemistry concepts understanding and summary writing between the SWH group and the traditional group. Second, there was significant difference in three groups chemistry concepts understanding, summary writing and academic achievement between the R-SWH group, SWH group and the traditional experiment group. Lastly, the SWH approach was effective in facilitating reflection. Specially, R-SWH approach was more effective in enhancing the fourth, fifth level reflection in analytical framework. This study suggests critical implications on college students' education in that the science learning was effectively performed when SWH, which emphasized on argument and writing, was integrated with the reading activity. The results show that R-SWH approach can be an effective teaching strategy for higher reflective thinking of learners without reference to the level of metacognition.

5. O1-A5

A LITERATURE REVIEW OF THE ROLE OF MORALITY IN TEACHING AND LEARNING SOCIO-SCIENTIFIC ISSUES

Jisun Park*, Jinwoong Song
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Since the 1980s, socio-scientific issues (SSI) have become focused in science education due to increasing the emphasis on scientific literacy. As for scientific literacy, dealing with SSI which entails the problematic situation is necessary to improve informed decision-making. This is distinguished from science-technology-society (STS) movement as SSI is embedded in a personal and social background and SSI education aims to empower students to take into account various aspects of issues including moral principles. The purpose of this study is to investigate what topics have been discussed in studies on socio-scientific issues that center on the role of morality. In this study, 37 papers related to SSI were selected among the articles published in international journals since the year 2000: International Journal of Science Education, Journal of Research in Science Teaching, Research in Science Education and Science Education. The results showed that twelve papers out of thirty seven were explicitly concerned in morality whereas rest of them considered it as peripheral in their studies. Many studies intended to conduct a comparative study in a quantitative way, including gender differences, secondary and post-secondary levels and teaching subjects by assessing the ability of each group to make a moral judgment. In contrast, there were few qualitative studies on how students considered moral aspects in decision-making. As for the context of morality in SSI the views on the nature of science (NOS), argumentation, informal reasoning and decision-making were referred to the article as key ideas and we discerned what moral aspects were reflected in conjunction with them. It was address that moral aspects were influential to decision-making and students took moral consideration based on utilitarianism in bio-ethical issues. As well, socio-moral themes were significantly dealt with during argumentation. As a reasoning mode, it was reported that clarification of value was important for moral development pointing out that people were reluctant to address their value. In regard to NOS, studies reported that both moral judgment and NOS played a role in decision-making but did not focus on its moral aspects of personal understanding of NOS (e.g. accurate measurement, reproducibility and academic honesty in science ethics). In addition, a few research delineated influential factors on moral reasoning of not only affective domains such as emotion and intuition but also socio-cultural domains like personal background, prior knowledge, family bias and impact of popular culture. In conclusion, the moral aspect of the SSI should be considered in science instruction. Further, the implication for the learning of SSI and the possible direction of the future research will be discussed.

- Oral Presentation 1-B
- Date: Wednesday, October 26, 2011
- Time: 16:40 ~ 18:20
- Room: #2 (1F)
- Chair: Youngshin Kim (Kyungpook National University, Korea)

6. O1-B1

ANALYSIS OF CHANGES IN THE ECOLOGICAL NICHE OF THE CONCEPT OF PHOTOSYNTHESIS IN 7TH GRADE THROUGH LESSONS

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The purpose of this study is to analyze how the ecological niche of the concept of photosynthesis in 7th grade changes due to lessons. The ecological niche was analyzed using 2 methods: (1) the change in the diversity of concepts, (2) the change in the proximity of concepts based on the frequency and the relativeness of the concepts. The concept of photosynthesis was analyzed in the 4 domains on the place of photosynthesis, products of photosynthesis, reactants of photosynthesis, and environmental factors. The results of this study are as follows: (1) reduced diversity of concepts, (2) increased frequency and relativeness of scientific concepts, and (3) increased proximity of scientific concepts due to lessons. With these results, the mutual effects of the concepts within the conceptual ecology have become active by class to differentiate the relationships between the concepts, which accordingly displayed the changes in their status.

7. 01-B2

COMPARING SCIENTISTS' VIEWS OF NATURE OF SCIENCE WITHIN AND ACROSS DISCIPLINES, AND LEVELS OF EXPERTISE

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Valarie Akerson
IUB, USA

Thai scientists from universities always involve in K-12 science education in Thailand. Therefore, understanding of their views of nature of science (NOS) should be investigated. The purpose of this study was to understand how Thai scientists from four disciplines viewed NOS. The sixteen participating scientists were chosen from the areas of chemistry, physics, biology/life sciences, and geology/earth sciences and were separated into novice and expert groups. The scientists' understandings about NOS were compared within and among the science groups as well as within and between novices and experts. All participants in the study had an opportunity to voice their opinions about the seven aspects of NOS that science educators in the United States have agreed should be taught in K-12 science classrooms. The scientists' views were found to be neither informed nor naïve but were a mix between the two. Many scientists' responses showed more naïve views with respect to tentativeness, subjectivity, social and cultural embeddedness, and the relationship between scientific theories and laws. The scientists' views about NOS differed with few observable patterns within or across disciplines. The novices' and experts' views of aspects of NOS were not substantially different. The scientists from both groups generally shared mixed viewpoints. Even though a few discipline specific patterns emerged from this study, cross disciplinary aspects of NOS in integrated science instruction is suggested rather than establishing particular concepts of NOS for each discipline so as to reduce complexity. Representatives of both novice and expert groups might be recruited to participate in developing new science curricula, teaching materials, and science teacher training programs. In addition, other factors need to be considered such as their knowledge of NOS, their willingness to get involved in science education at the school level or teacher education program, and their willingness to cooperate in the multi-step tasks of curriculum development.

8. 01-B3

INVESTIGATION OF THE EFFECTS OF A VISUALISATION-BASED MULTIMEDIA INSTRUCTIONAL PROGRAM ON STUDENTS' UNDERSTANDING OF MULTIPLE REPRESENTATIONS IN ELECTROMAGNETIC INDUCTION CONCEPTS

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Nanyang Technological University, Singapore

A mixed quantitative-qualitative case study design involving 32 Year 11 Singapore students was used to evaluate their understanding of macroscopic, microscopic and symbolic representations in electromagnetic induction concepts. The general electromagnetic induction concepts were introduced using a visualisation-based multimedia instructional program that was developed by the authors. The instruction involved the student-centred teaching approach such as group activities and discussion based on provided visualised material - video clips, PPT slides, teachers' demonstrations and hands' on activities using data logger. A pretest questionnaire consisting of ten multiple-choice items that required open-ended justifications was administered before instruction. After four hours of instruction, the same questionnaire was administered as a posttest together with five additional items from the Singapore-based national examinations to find out the correlation between students' understanding of multiple representations and their problem-solving ability. Nine students were also interviewed at the end of instruction. The findings showed higher scores in posttest than pretest that were statistically significant [Pretest: Mean =0.45, SD = 0.19; Posttest: Mean =0.61, SD = 0.18]. However, most students showed limited understanding of the use of multiple representations from the open-ended justifications and interviews. Students' explanations were generally mechanical and there was statistically significant weak correlation between students' understanding of multiple representations and their ability to solve exam questions. Also, further research is needed in designing instructional programs that would better facilitate students' understanding of multiple representations in electromagnetic induction.

9. 01-B4

USING VIDEO ANALYSIS AND COGENERATIVE DIALOGUES TO EXPAND SCIENCE TEACHING AND LEARNING OPPORTUNITIES FOR TEACHERS AND STUDENTS IN URBAN SCHOOLS

Sonya Martin*
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Teacher turnover is an issue in many parts of the world; however, it seems that schools in large urban areas are particularly plagued by the problem. Urban centers in the United States currently face numerous problems, one of which lies in attracting and sustaining quality teachers, especially in the areas of math and science (Darling-Hammond, 1997; Ingersoll, 1999; 2000; 2003). Beginning teachers entering the field of teaching face overwhelming challenges, including struggling to balance content planning, instruction, and other professional responsibilities; any number of which could serve as motivating factors for them to leave. However, new teachers have an especially difficult time maneuvering and adapting well to urban school environments as they often lack the ability to appropriately interpret and interact with the youth who often differ from teachers in terms of culture, ethnicity, race, and socio-economically. Unfortunately, the combination of this isolation and cultural incongruence often set these new teachers up for failure and eventually an exodus from teaching (Cattani, 2002). A growing number of researchers and teachers in science education have begun to understand the benefits of capturing and evaluating activity through the use of video (Martin & Siry, 2008), which allows researchers and teachers to analyze science teaching and learning activities to maximize teacher and student success. When teachers engage students in discourse around a shared event through cogenerative dialogues, students and teachers are able to apply different theoretical lenses to examine interactions captured through video, which can lead to transformations of teaching and learning practices within that classroom (LaVan & Beers, 2005). Cogenerative dialogues are structured conversations where teachers and students engage in discourse with the intention to co-generate shared understandings about classroom interactions and student/teacher goals (Martin, 2006). Spanning various urban high school contexts and a period of five years, this critical ethnography (Barton, 2001) documents and analyzes various interactions between new teachers and students both in the contexts of urban classroom teaching, one-on-one and small group cogenerative dialogues, and in a teacher education course in which pre-service teachers discuss video of themselves teaching in urban high school science classrooms. Findings indicate that video analysis and cogenerative dialogue offer new teachers structural supports which enable them to expand their professional roles, critically reflect on their teaching with others, cross cultural and social boundaries by increasing their knowledge about urban life, and foster collective responsibility for classroom teaching and learning. This presentation offers important implications for urban teacher education programs that seek to prepare new teachers who have knowledge of both practical teaching skills and a means to reflect upon and adapt their teaching practices over time, as well as expand learning opportunities for urban youth. This research offers tools not only for teacher-researchers interested in transforming their practice, but also for teacher education programs who can educate pre-service teachers to evaluate their teaching using video of their classrooms discussed in cogenerative dialogues, in an effort to help new teachers develop and nurture a reflective voice, a skill that they can rely upon throughout their careers.

10. 01-B5

VALIDITY AND RELIABILITY OF THE SCIENCE MOTIVATION QUESTIONNAIRES WITH KOREAN COLLEGE STUDENTS

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Becoming scientifically literate citizens who are able to understand the scientific issues is essential point of the science education. As college science instructors respond to the need for fostering students' scientific literacy, the important role of students' motivation has received increased. This study examined how Korean college students, who enrolled in a general education science course, conceptualized their motivation to learn science. The 523 Korean college students completed the Science Motivation Questionnaires (SMQ, Glynn & Koballa, 2006). In order to exam construct validity, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were performed. The result of EFA and CFA revealed that the students' conceptualization of their motivation to learn science in five dimensions: intrinsic motivation and personal relevance, self-efficacy and assessment anxiety, self-determination, career motivation, and grade motivation. There are gender differences within the each five sub dimensions and overall motivation to learn science. Based on the findings, we discussed follow-up research and collage general science course development. Glynn, S. M., Koballa, T. R., Jr.(2006). Motivation to learn college science. In Jouel. Mintzes and William H. Leonard (Eds.) Handbook of College Science Teaching (pp.25-32). Arlington, VA: National Science Teachers Association Press.

- **Oral Presentation 1-C**
- **Date: Wednesday, October 26, 2011**
- **Time: 16:40 ~ 18:20**
- **Room: #3 (1F)**
- **Chair: Yoon Fah Lay (Universiti Malaysia Sabah, Malaysia)**

11. 01-C1

AN INVESTIGATION ON THE RELATIONSHIPS BETWEEN PRE-SERVICE SCIENCE TEACHERS' SCIENCE TEACHING EFFICACY BELIEF AND SELF-IMAGE AS SCIENCE TEACHERS

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Self-efficacy and attitudes of pre-service teachers have been the focus of many studies. This is mainly due to the expected effect these might have on teachers' behavior in classroom teaching. Low self-efficacy beliefs and negative attitudes could have varying classroom effects from less time teaching the subject, employing didactic approaches, affecting student achievement to passing on to students' negative attitudes towards science and teaching. The purpose of this study is to investigate the probable relationship between pre-service science teachers' self-efficacy and perceptions of self as science teachers, which both measure issues related to the expected behavior teachers adopt when teaching science. In this study, self-efficacy will be measured using the Science Teaching Efficacy Belief Instrument, Form B (STEBI-B) developed by Riggs and Enochs (1990). The STEBI-B consists of 23 statements which are divided to provide two sub-scores which are randomly embedded in the instrument. Thirteen of the statements yield scores for the Personal Science Teaching Efficacy (PSTE) subscale, which reflect science teachers' confidence in their ability to teach science. The other ten statements yield scores for the Science Teaching Outcome Expectancy (STOE) subscale, which reflect science teachers' beliefs that student learning can be influenced by effective teaching. The 'Draw-A-Science-Teacher-Test-Checklist' (DASTT-C) will be used to measure perceptions of self as a science teacher (Thomas & Pedersen, 1988; Thomas, Pedersen, & Finson, 2001). Students will be instructed to draw a picture of a science teacher at work and write a brief explanation describing their drawings and specifically answer the questions, "What is the teacher doing?" and "What are the students doing?" regarded their drawings. The DASTT-C consists of three sections: (a) Teacher, including two subsections, teacher's activity and teacher's positions; (b) Student, including two subsections, student's activity and student's position; and (c) Environment, including 5 subsections, desks arranged in rows, teacher desk, lab organization, symbols of teaching, and symbols of science knowledge. Pearson product moment correlation will be used to determine if there is a significant relationship between pre-service science teachers' self-efficacy and perceptions of self as science teachers. The STEBI-B and DASTT-C are essential instruments that can be used to help to develop techniques and procedures for promoting reflection and analysis of pre-service science teachers' beliefs and thinking. Exploration of pre-service science teachers' beliefs of science teaching plays a vital role in their acquisition and interpretation of knowledge and subsequent teaching behavior. It directs science educators to devote efforts for changing pre-service science teachers' beliefs to more insightful learning experiences in the teacher preparation programmes.

12. 01-C2

ELEMENTARY TEACHERS' CONCEPTIONS OF SCIENCE INQUIRY TEACHING: CASES OF SOUTH KOREA, SINGAPORE AND UNITED STATES

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With a long history, science inquiry has been a primary goal of science education in international communities of science education. Given that its vision has been promoted internationally and its implication has been a challenge in local classrooms, this study aims to understand how elementary teachers perceive science inquiry teaching and what could be suggested to develop inquiry teaching in their educational contexts. The study invited elementary teachers in three different countries, Singapore, South Korea, and the US. We attempted to understand what are the similarities and differences in teachers' conceptions of inquiry teaching in relation to curriculum reformation, classroom practice by engaging them in survey questionnaires, inquiry scenario survey, and narrative writing on inquiry. The data was analyzed from both normative and emic perspectives. The findings suggest teachers' perceptions of inquiry are confined to traditional views of inquiry across the countries, yet, embedded in the vision of inquiry stated in their curriculum and educational contexts. We discuss implications for professional development about inquiry teaching as well as improvement of educational context in each country.

13. 01-C3

A PD MODEL OF TEACHERS FOR PROMOTING UNDERSTANDING OF SCIENCE

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With the newer educational demands, assessment of students' attainment are to be made more valid, particularly through continuous school-based assessment with intervention strategies used to promote better understanding in students. A professional development (PD) programme was piloted with one secondary school to: (1) diagnose students' science achievement through valid and reliable assessment; (2) promote and practice teaching and learning strategies that are appropriate in order to promote better understanding of science for all students; (3) peer coach the head of science department to guide science teachers in promoting understanding of science concepts with their students. Data from the PD of four teachers with the head of science department were collected from videotapes of lesson plans, observed lessons and meetings that were held. Analyses of the qualitative data involved identifying patterns of teaching and learning elements and comparing lessons before and after one peer coaching cycle with each teacher and other related factors. Quantitative data were statistically analysed for students' achievements before and after the lessons. Results of the pilot study provided lessons learnt for further refinement of the model for the professional development of the science teachers and peer coaching of head of science department proposed.

14. 01-C4

DEVELOPMENT OF A PROFESSIONAL DEVELOPMENT MODEL FOR IMPROVING SCIENCE AND MATHEMATICS TEACHING IN THAILAND

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The Professional Development Model comprises a Curriculum Design Team (CDT), Professional Development Leaders (PDLs), a Mentoring Team (MT), and the Science and Mathematics Teaches Network (SMTN). It is a 5-year project launched in 2006 and piloted in ten provinces throughout the country involving 1,700 primary and lower secondary schools and 8,500 teachers. The CDT comprises science educators from both the participating universities and IPST. They are responsible for developing effective curriculum materials and for training the teachers. The PDLs are scientists, science educators from universities and IPST, and outstanding teachers. They are responsible for designing the mentoring program, training the mentors and the school principals, and following up. Teachers selected from the pilot schools constitute the MT.

They are being trained for mentoring the teachers (mentees) in the voluntary pilot schools. The mentoring program includes effective teaching strategies and learning activities, classroom research experience, mentoring strategies, classroom observation techniques to enhance teaching and learning. The SMTN was developed as a learning community for sharing practices of teaching materials, teaching and learning activities, and research through conferences, workshops, and digital network among the CDT, the PDLs, the MT, and the mentees. According to the project evaluation, the model is effective and sustainable. The CDT and PDLs work together to improve science and mathematics education. The mentors play a very important role in enhancing teaching and learning. The mentees have been improving their teaching techniques. The students' achievement has met the criteria. The school principals are paying more attention to academic affair. The learning community and the networks work well and are sustainable. The model is considered a policy research and has been implemented by other professional development projects of IPST especially the Project on Improving Teaching and Learning Science, Mathematics in the Southern Border Provinces of Thailand, launched in 2008. The curriculum for teacher training and teaching and learning activities for this project have been specially designed to comply with the national standards taking into consideration factors of cultural sensitivity. Community involvement and collaboration with universities in the project areas as well as indigenous knowledge have been focused on improving education and learning and work opportunities of young people. The education supervisors from the local education areas have been trained and involved in the mentoring program. The project is still going on and the results of the follow-up program points to positive outcomes regarding teachers' performance, students' achievement and attitude toward science, mathematics and technology. A Center for Science and Mathematics Education in collaboration with universities in each project area is under consideration for establishment. The model has also been implemented through the Leader for Change in Teaching and Learning Science and Mathematics Project, the UPGRADE Project and the ETV Project.

15. 01-C5

EXPLORE CHEMISTRY TEACHER'S TEACHING CONCEPTIONS SYSTEM DIRECTING TO TEACHING BEHAVIORS IN THE CONTEXT OF NEW CURRICULUM REFORM IN CHINA

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The problem that teachers transform their teaching conception to teaching behaviors has been one of the hot research issues in the background of New Curriculum Reform in China. Researchers found that what teachers say not accordance with what teachers do, and what teachers say not accordance with what teachers believe. Researchers also found what people believe affect people's behavior. So how teaching conception can be transformed into teaching behavior, and why some teacher can transform conception into behavior easily. This research is to explore the system of teaching conception that directing teaching behavior. This research constructed the concrete model for teaching conception system based on literatures and observations for the middle school teachers made by the author. This conception system could be described as: the values and basic functions that teachers hold must be in accordance with the teachers' basic recognition to education and pedagogy which is the core to teachers' teaching conceptions, when teachers expect to present a certain concrete teaching conception to the teaching behavior; the teachers' concrete teaching conceptions have been stored by declarative cognition, procedural cognition and conditional knowledge, experienced schema; the declarative cognition indicates teachers'' basic understanding to teaching conceptions, it is the pre-condition to the existence of procedural cognition and conditional knowledge, experienced schema; the procedural and conditional cognition have an impact to information sift and processing in the period of the formation of the experienced schema which must meet the requirements of procedural cognition and conditional knowledge; at the same time, when the schema continually enhance and develop, the procedural and conditional knowledge get improved and developed successively; the more plentiful schema teachers' have, the easier transformation will occur. This research made the questionnaire of the core teaching conception system and the concrete teaching conception system based on the indicators focusing on teaching value, teaching aim and teaching subjectivity, by using statistic analysis to the concrete teaching conception system model directing to teaching behaviors. The questionnaire included seven parts, the first part described the basic information of teachers, and the second to the seventh contain three core teaching conceptions and three concrete teaching conceptions. The validity and reliability are acceptable. The samples are those teachers who attended the web-based study for chemistry curriculum organized by Department of Education and those by organization of Shandong province in 2010. The valid questionnaire samples are 7571. The conclusions are below: **1.** The core teaching conceptions have the predictions to the concrete teaching conceptions; **2.** Each teaching conception teachers' have contain the different forms such as the concrete declarative, procedural and conditional, the schema; **3.** Teachers' core teaching conceptions have the main influence when teachers use the different forms of the concrete teaching conceptions, thus the different declarative conceptions (teachers' prostrations) and the procedural and conditional, schema (teachers' actual behaviors) have been expressed. **4.** The concrete teaching conceptions teachers' hold have the relationship, among them, a teaching conception of teachers' understanding to enhance students' understanding has the greatest effect to the others. **5.** Teachers' teaching conceptions have significance with teachers' teaching behaviors. Schema has a more significance to teaching behaviors.

- **Oral Presentation 1-D**
- **Date: Wednesday, October 26, 2011**
- **Time: 16:40 ~ 18:20**
- **Room: #4 (2F)**
- **Chair: Malinee Chaiyabang (Khon Kaen University, Thailand)**

16. 01-D1

EXPLORING THAI ELEMENTARY SCHOOL TEACHERS' UNDERSTANDING OF CONCEPTS AND INSTRUCTION OF THE NATURE OF SCIENCE

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This study aimed to explore Thai elementary school teachers' understanding of concepts and instruction of the Nature of Science and their teaching practice. Based on the interpretive paradigm , the journeys of the participant teachers were explored and described. The study examined the views of 320 elementary teachers in the Northeast of Thailand regarding their NOS understanding and teaching practices were employed Semi – structured interviews, the VNOS –C questionnaire and classroom observation. Findings from the study revealed that teachers' views of the NOS ranged from traditional to contemporary. They did not recognize or appreciate the need to understand the NOS as a learning outcome that required explicit teaching and assessment. They did not emphasize concepts of the nature of science as their goals of instruction. Rather, they reported using implicit approaches for teaching the NOS with an emphasis on studying scientific concepts and less emphasis on doing scientific activities. This study provides empirical evidence that teachers' understanding of the nature of science 'concepts and instruction in Thailand was generally inadequate for science teaching. It is proposed that NOS should be promoted to be taught using explicit and reflective instructional approaches within teacher development programs based on social constructivist perspectives and focusing on explicit approaches for understanding the NOS' concepts and instruction.

17. 01-D2

THE HISTORY OF SCIENCE APPROACH TO THE NATURE OF SCIENCE : GALILEO'S DISCOVERY OF MOONS OF JUPITER AND THE RETURN OF HALLEY'S COMET

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The aims of this study are to investigate the history of science appeared to be a nature of science, because historical reading combined with investigative experimentation, especially of a historical nature, appears to be a promising way for students to learn the basics the scientific method and understand someone other issues of the nature of science, based on especially the heliocentric theory of Copernicus and the return of Halley's Comet. They provide an opportunity to talk about the meaning of theory to be tentative. Time is sometimes taken out of context within science education when scientific concepts that have developed slowly and are well accepted by scientists are treated as though they were tentative.

18. 01-D3

INTEGRATING WEBQUESTS INTO CHEMISTRY CLASSROOM TEACHING TO PROMOTE CRITICAL THINKING

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The WebQuest is a student-centered, inquiry-oriented and project-based approach for teaching and learning activity that students use Web resources to learn school topics. This article reports on the design, implementation and evaluation of a WebQuest teaching approach for chemistry classroom teaching in improving the critical thinking of high school students. A pre- and post-test design was used where 4-month long-term WebQuest teaching approach with five chemical topics was offered to 50 high school students aged ranged from 16 to 17 years in Xi'dian Middle School attached to Xidian University in Shaanxi province of China. The California Critical Thinking Disposition Inventory (CCTDI) and the California Critical Thinking Skills Test (CCTST) were employed as data collection tools. Both CCTDI and CCTST scores of the participants showed significant differences ($p < 0.05$) between before and after WebQuest learning. The subscale scores of CCTDI showed significant differences in all aspects of dispositions toward critical thinking except open-mindedness and maturity. For CCTST subscales, the scores showed significant differences in analysis and evaluation but in inference. These findings add to the evidence that integrating Webquests into science classroom teaching might be an effective way to develop high school's students' critical thinking.

19. 01-D4

TEACHERS' CONCEPTIONS OF TEACHING AND LEARNING WITH INTERNET RESOURCES IN SCIENCE INQUIRY CLASSROOMS

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This paper reports the results and findings of an online survey designed to explore in-service primary science teachers' conceptions of the use of Internet resources in science inquiry learning. The survey consists of 75 items focusing on six areas regarding inquiry learning in science and the use of Internet resources – (1) teachers' conception of inquiry learning by primary learners, (2) misconception of inquiry learning, (3) perceived difficulty in adopting inquiry learning, (4) use of different Internet resources, (5) use of Internet resources in their teaching, and (6) resistance to using Internet resources. The items are developed with reference to a number of related surveys and discussions. A 4-choice Likert scale has been adopted for the responses to each item.

SPSS 17 has been used to analyse the data collected from 76 teachers. Interviews are conducted with volunteer respondents to gain a deeper understanding of teachers' conception in each area and selected items. Initial findings suggest that the teachers understand inquiry-based learning and teaching quite well and their views towards using Internet resources in inquiry learning are quite positive, indicating teachers' willingness to adopt Internet resources in their teaching despite the difficulties encountered. One of the biggest issues hindering teachers' use of Internet resources is that it is very time consuming to look for appropriate resources from the Internet, reflecting the need to offer help to teachers in searching, selecting and using Internet resources. Individual responses are also found to be correlated to different background information of the teachers, for example, teachers with a science background use online statistical data more frequently than those without.

20. 01-D5

TEACHING BIOLOGICAL PROCESSES USING CURRICULUM MATERIALS BASED ON 3-D COMPUTER ANIMATIONS

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Many high school students experience difficulties when learning how the organs and tissues of the body function. This research examined how the creation/testing of interactive case study modules that combined dynamic 3-D models and inquiry-based learning can demonstrate the value of integrating technological tools for teaching these biological functions. In an effort to support inquiry-based science activities for high school students, a University of Georgia research team has developed three examples of animation-based curriculum modules. The team aimed to create interactive 3-D models and environments with which students can explore and interact, and not simply learn by watching animation movies. Each animation curriculum module includes a case study that directs the student's attention to an animal or human, a specific disease state, and a biological process. In this approach, students are placed in a scenario in which an animal is afflicted by a particular health condition that is caused by some fundamental process of biology such as osmosis. The students' goal is to determine the underlying cause of the problem and to solve the problem using medical diagnostic tools and treatments available through the different sections of the module. Although the software and hardware available in science classes are important components of instruction, teachers play a critical role in the integration of new technology-based curriculum materials into that instruction. In many schools, teachers have access to an array of instructional technology, but there has been little evidence showing that technology-based curriculum materials are being fully integrated in the curriculum on a regular basis. The research study being reported here examined how the interactive case study modules were incorporated into the teaching of introductory biology in six U.S. high schools. Using a multiple case study methodology, this study investigated teachers' experiences with the 3-D animations-based modules. For this study, the participant teachers taught the biology content of osmosis using one of the curriculum modules called Clinical Clark. Each participant teacher's instructional activities was observed in their natural teaching environment as they planned for, taught, and reflected on a series of lessons that use the 3-D animation curriculum materials. This presentation will show examples of the animations and discuss issues related to teachers' implementation.

- **Oral Presentation 1-E**
- **Date: Wednesday, October 26, 2011**
- **Time: 16:40 ~ 18:20**
- **Room: #5 (2F)**
- **Chair: Hang-Hwa Hong (Western Michigan University, USA)**

21. 01-E1

DEVELOPING TEACHING MATERIALS OF SCIENTIFIC CREATIVITY RELATED TO BIOLOGICAL CONTENTS AND PILOT APPLICATION TO GIFTED SCIENCE STUDENTS

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In order to develop students' scientific creativity, teaching materials are developed based on both Cognitive Model of Scientific Creativity (CMSC) and a model of IAGA. In this study, we introduced developed materials and discussed the result of pilot application to gifted science students. There are four complete topics related to biological contents that can be used to effectively stimulate scientific creativity in gifted students. They have been developed a student's worksheet and a teacher's guide. For the pilot test, we used only three topics: one for the level of elementary and two for the level of middle school. Twenty four students of a University Center for Gifted Science Education participated: sixteen students from elementary schools and eight students from middle schools. Results show those students have interest in inquiry activities of the three topics. However, these tasks presented difficulty to students who lack a deeper knowledge of biology. These students preferred not to complete those activities. Thus, in order to educate creative thinking skills for gifted students teaching materials should include biological contents and inquiry activities. The developed handouts and guides from this study will be helpful in practical classes for all students.

22. 01-E2

CHARACTERS OF SCIENTIST'S PROBLEM FINDING AND SOLVING ACTIVITIES COMPARED WITH THOSE OF HIGH SCHOOL STUDENTS

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Korean national curriculum for secondary school emphasizes the ability of scientific problem solving. Most of researches have studied how secondary students solve the scientific problem which was proposed by precedent scientists. Scientific activities are what are performed not only by past scientists but by present scientists. Therefore, it needs to study the activities and characters of present scientists and to compare with those of secondary students. This is the study to interview the present scientists and high school students. Both of them were asked what was most important to find their scientific problems, which criteria made them find and modify their problems, which information was most important to find and solve their problems, and what strategy was chose to solve their problems. Results indicated that problems and solutions of scientists and students were influenced by background knowledge of the tasks. Students screened information browsed on the Internet, and applied some standards for selection. Scientists didn't select the information artificially, because they were trained to choose the right information.

23. 01-E3

TYPES OF MODELS AND MODELING BEHAVIOR OF BIOLOGY MAJORS: IMPLICATIONS FOR CRITICAL THINKING DEVELOPMENT

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Identifying and investigating student-generated models and their modeling behavior have implications for critical thinking development. Thus, this paper describes the types of models that biology majors use including their modeling behavior in learning key concepts in biology such as the cell membrane, cytoskeleton and cell structure. Initially, a total of 44 biology students from all year levels who were enrolled in the second semester of calendar year 2008-2009 were asked to make their respective models of the cell membrane, cytoskeleton and cell structure. This was followed by having them complete an open-ended questionnaire. In the second phase of the study, five students from each year level were randomly selected for a one-on-one interview. Data from the modeling activity and open-ended survey questionnaire were analyzed using Harrison and Treagust's typology of concept-building analogical models as basis for identifying the type of model biology students used. Results showed that the student-generated models from all year levels were mostly analogies, some textbook definitions and occasional drawings. However, the familiarity that students have with a wide range of models was notable. The modeling behavior of students mainly consists of first, text reading or memory recall; second, outlining of similarities in function, structure and composition or both; and third, making the model, which for many of the student-generated models were in the forms of analogies and some drawings. Data suggest that models are good diagnostic tools. The critical thinking skills of students mainly revolve on recognizing similarities in structure and function between the concept and their model. More opportunities for student-generated models must be available if students were to develop integration and reflective thinking in their models, as some senior students were found to demonstrate.

24. 01-E4

THE EFFECT OF "LEARN TO THINK" CURRICULUM ON THE SCIENTIFIC CREATIVITY OF SECONDARY SCHOOL STUDENTS

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The "Learn to Think" (LTT) Curriculum was developed by author. There is one book for each grade from grade 1 to grade 8 and has been implemented in more than 200 primary and secondary schools in 10 years. Several longitudinal intervention studies show that LTT can promote the development of students' thinking ability, learning motivation, learning strategy and raise academic performance. This paper describes a study of the influence and the delay effect of LTT Curriculum on the scientific creativity of secondary school students. 110 students were randomly selected from a middle school, 56 of them participated in the LTT curriculum every 2 weeks and the left had not. The experiment last two years. The Scientific Creativity Test for Secondary School Students was used for pre-test, mid- test and post- test. The delayed effect was explored half a year after terminating the intervention. The results indicated that the LTT curriculum did promote the development of scientific creativity of secondary school students, and the effects on the scientific creativity were not necessarily immediate, but tented to be long-lasting.

25. 01-E5

INVESTIGATING IN STUDENTS', TEACHERS' AND PARENTS' RECOGNITION ABOUT CONTRARY VIEWS ON SCIENTIFIC CREATIVITY

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Even though many people have interested in scientific creativity, there are various contrary opinions. Therefore, the purpose of this study is to investigate the students', teachers' and parents recognition about those contrary views on scientific creativity. To develop the questionnaire, at first, we obtained various responses form 40 science teachers using open-ended question asking to write what they think about the creativity freely. Based on teachers' responses, Park's model of scientific creativity (Park 2004), and literature review regarding to the scientific creativity, we developed questionnaire consisting of 16 contrary statements describing various characteristics of scientific creativity. The 16 contrary statements are regarding to (1) The scientific creativity can be nourished by education and training, (2) The process of generating scientific creativity ideas is mysterious one, (3) Gathering many ideas can lead to generate new idea, (4) The scientific creative person is unstable mentally, (5) Simple scientific creative ideas are better, (6) For scientific creative ideas, various knowledge and experience in other fields can be helpful, (7) The scientific creative ideas can be originated by existing ideas, (8) The scientific creative ideas come to mind suddenly, (9) The person with IQ of 150 is more creative than the person with IQ of 120, (10) Scientific discovery can be said to be creative only when it is recognized and appreciated by science commun-

ities, (11) The scientific creative ideas can come through fluency and flexibility thinking, (12) The Scientific creative idea is different from logical thinking, (13) The creative person in scientific field are creative also in other field, (14) The creative scientists leave a lot of ordinary works as well as greatest works, (15) The creative ideas in scientific field come through non-daily and vagarious thought, (16) The scientific creativity can be shown from genius like a Einstein. The responses of the questionnaire were obtained from 300 students, 100 gifted students, 100 pre-service teachers, 100 teachers, and 100 parents. As a result, students', teachers' and parents have different recognition about (2), (13), (15) statement. Besides this, other interesting result will be presented.

- **Oral Presentation 1-F**
- **Date: Wednesday, October 26, 2011**
- **Time: 16:40 ~ 18:20**
- **Room: #6 (2F)**
- **Chair: Hongming Ma (Monash University, Australia)**

26. 01-F1

USING NATIVE KNOWLEDGE TO EXPLORE SCIENCE TEACHERS' UNDERSTANDING OF THE NATURE OF SCIENCE: A CHINESE STUDY

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Research on the nature of science in the field of science education has been done for several decades. Although numerous studies have been carried out, there is much less research of this kind which concerns cultural influences on the understanding of the nature of science. This paper presents a research study that adopted Traditional Chinese Medicine (TCM) as a means to elicit science teachers' understanding of the nature of science. The purpose is not to portrait a thorough image of science held by the participant teachers, rather, it is expected to explore teachers' functional understanding of some aspects of the nature of science in a context within which both native knowledge and 'Western modern science' are presented. A semi-structured in-depth interview protocol was adopted. 25 Chinese secondary school science teachers were involved in the study. The findings show that no clear distinction was made between science and non-science when some of the 'unique concepts' at the heart of TCM were involved in the discussion. 'Practice and experience' were equally valued as valid scientific methods. Both universalist and multiculturalist inclinations among the participant teachers were identified. This study shows that native knowledge can be valuable as culture-specific material for discussions about the nature of science – putting different knowledge systems together in the discussion about the nature of science may facilitate the recognition of the culture-based nature of both native knowledge and Eurocentric science.

27. 01-F2

IN BETWEEN SCIENCE AND PEOPLE: A COMPARATIVE LIFE STORY OF THREE BRITISH SCIENTISTS WHO HOPED TO CHANGE THE SOCIETY

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The Industrial Revolution was a critical moment in history in which the relationship between science and society was changed fundamentally. Before that, science had been mainly human intellectual endeavors to search for the unknown secrets of the outer worlds, either of the god or of the nature. After the Industrial Revolution, science was no longer something to do with superhuman affairs, but became rather a significant means through which the destiny and opportunity of a society and its individuals could be determined or altered. This study attempts to tell a comparative life story of three British scientists (G. Birkbeck, T. H. Huxley, and L. Hogben) who lived during the period of apparent social class conflicts, from the Industrial Revolution to World War II, and hoped to change the society with a help of science. George Birkbeck (1776-1841) was a successful physician and a philanthropist who started free science evening classes for the working class, then known as mechanics. He is widely known as a founder of British adult education, with recognition of his pioneering efforts to establish London Mechanics' Institution and to initiate and spread a worldwide 'mechanics' institute movement' which aimed to 'diffuse useful knowledge for the poor' and flourished during the first half of the 19th century. Thomas Henry Huxley (1825-95) was one of the most influential Victorian scientists, a zoologist commonly known with his nickname 'Darwin's Bulldog'. He was a typical self-made scientist and became a very high-profile science statesman as well as a reformer of British education. His efforts were largely made to secure the places of science in society and in school curriculum against the domination of the cultures of gentleman and of classics. Lancelot Hogben (1895-1975) was one of the key figures of a group of socialist scientists who played important roles around the periods of World War I & II. As a biologist, he was critical to then a widely accepted view of eugenics and strongly against the idea of totalitarianism like Nazism. While maintaining his career as an active researcher, he also made a great effort to write popular science and math textbooks particularly for helping the self-study of the working class. In this study, despite considerable differences in social, scientific and education backgrounds between the historical periods of the three, their life stories will be re-grouped, compared, and reinterpreted around the following aspects: what were the historical situations of society of the time and were their family backgrounds? How were they trained as scientists and why did they become interested in society? What were their major activities as science educators and in doing so within which social network did they work? What kind of society did they dream of and why did they think science is important? Where did they stand in between science and people and why?

28. 01-F3

TO EXPLORE THE EEG ALPHA AND THETA ACTIVITY DURING PROCESSING OF BIOLOGY CONCEPTS

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There are many kinds of informational input while students learn scientific concepts. According to the Baddeley's model of working memory, there are dual modalities for information processing, one is the visual spatial sketchpad that is for visual and spatial information processes, the other is the phonological loop that is for verbal and text information processes. Based on the Baddeley's working memory model, the purpose of this study was to explore the electroencephalographic (EEG) activity while students were involved in the cognitive processes of biology conceptions. In this study, the biology conceptions were displayed in three different conditions: pictures, low Imaginable words and high imaginable words. The experiment procedure followed the Sternberg task paradigm, in which the students were instructed to respond whether a probe item was one of the encoding items presented previously. There were sixty-six science major undergraduate students who participated in this study. All of the students were asked to receive the experiments that consisted of three different conditions. During the experiment period, students' EEG data were recorded, and later on analyzed across the three different conditions. The results showed greater theta power increase in low imaginable words and high imaginable words conditions than in the pictures condition. According to previous studies, the frontal theta power increase is an indicator of mental effort and working memory demands. In this way, it means that students took more mental activity and working memory demands while receiving the biology concepts in low and high imaginable words than in pictures. In addition, our study results also showed parietal alpha power decrease across three conditions, and the parietal alpha power in the picture condition was more decreased than low and high imaginable words conditions. In previous studies, the important function of parietal area was to guide the visual attention to the intended area. The phenomenon of parietal alpha power decrease was evident in studies in which subjects were involved in the visual spatial attention tasks. That means in our study, the subjects showed higher visual spatial attention demands while biology concepts were presented in the picture mode than presented in word mode. In conclusion, the study results indicated that students showed higher visual spatial attention demands when the biology concepts were presented in picture mode, and higher mental effort and working memory sustained demands while the biology concepts were displayed in word mode regardless of whether they were low or high imaginable.

29. 01-F4

EXPANDING STUDENTS' VIEWS OF SCIENCE THROUGH PERSONAL SCIENCE NEWS CONSTRUCTING

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During our everyday life, there are so many issues related to science. Are our foods, water, and air healthy or not? Is our environment threatened by toxins or by some chemical elements? How will the most recent technology development affect human beings now and in the future? …These so-called socio-scientific issues arise almost every day, and always have strong connections with individuals and society. An informed and socially responsible individual must possess a great deal of scientific literacy in order to cope with these changes and their effects. Science news is the most important and convenient materials available. With it, the public could achieve a certain level of literacy due to its updated and accessible features. This study plans to change students' views of science via science news reading and personal science news constructing. All the participants were selected from students enrolled at the university-level within a general education program in Taiwan. This study is divided into three phases. First, students need to read science news and 'guesses' on the invisible processes behind this news report. Second, following group discussions, students are required to write science news reports on their own favorite issues as homework. Third, students must upload their final reports to the class website. There, students will find exhibits and interactive functions that permit them to share different topics and perspectives. Both of qualitative and quantitative data was collected. Preliminary results have already shown that the science news based teaching can efficiently expanding our students' views of science.

30. 01-F5

BRIDGING THE GAP BETWEEN FORMAL AND INFORMAL SCIENCE EDUCATION FROM WEATHER LITERACY

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The purpose of this study was to understand issues about "weather literacy" under social culture in two dimensions, journalism communication and science education. It emphasized the importance of public's weather literacy, and also tried to reveal the status by four fields, to highlight the gap between formal and informal science education. At first, this study discussed the mechanism of weather forecast in terms of social cognition on the "88 Flood" disaster precipitated by Typhoon Morakot in recent Taiwan. Second, this study selected and compared 100 contents of typhoon warnings released by Central Weather Bureau's and 7 e-news related. We found the existence that different databases may lead to different characteristics and show the dilemma in their communication presentation. Third, it discussed weather concepts in formal science education and then showed education nowadays in weather literacy with some possible lacks. Finally, with the analysis on the nature of predictability in scientific knowledge of weather based on the epistemology view of scientific philosophy, it brought up some possible approaches to promote weather literacy teaching in the future. In conclusion, in order to enhance the public understanding of scientific knowledge and journalism in weather forecast, we should scheme out suitable teaching modules and strategies in science education that bridging the gap between formal and informal science education as soon as possible. Such strategies should carry out weather concepts with science communication. Through this approach, the accessibility of weather communication to public will be improved and promote public understanding of science (PUS) and weather literacy in our daily life.

- Poster Exhibition 1-A
- Date: Wednesday, October 26, 2011
- Time: 14:20 ~ 15:20
- Room: Main Room

1. P1-A1

APPLICATION OF PROBLEM-BASED PROJECTS TO INCREASE MEANING-MAKING IN THE SCIENCE CLASSROOM

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Teaching methods like "inquiry-based," "problem-based" and "theme-based" learning have been coming to the forefront as teachers try to help students take a deep level approach to understanding. With this objective in mind we used a problem-based storyline on sickle cell anemia developed by the MDBio Loaner Lab and extended it in some areas to become an on-going project that was revisited throughout the genetics unit, allowing students to go back, re-access prior learning and apply it to different facets of the problem. Although only a third of students scored the activity as something that they would like to do again and there was no impact on content assessment scores, our assessment of the reflective comments and our impressions from observing students processing, integrating, discussing and generating ideas made us confident that students were getting important practice in the primary objective.

2. P1-A2

ANALYSIS OF VERBAL INTERACTION ON THE PROCESS OF ELEMENTARY STUDENTS' HYPOTHESIS GENERATION LEARNING

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I started a project including a new web site where child-care support people including teachers and parents exchange and develop idea of astronomy education for children especially in informal settings. I have visited a nursery school in Osaka Prefecture, Japan, and enjoyed "star and sky play" with 3, 4, 5-year-old children and their teachers and parents, and I have observed the nursery children in detail. However, it is not easy that the results be shared with other nurseries and groups which help the child care. The reasons are that the field of star and sky is not so popular to preschool teachers and that in Japan not all preschools are strongly under the control of the bureau which can have a well-organized information system. The web site which has science education supervisors can solve this problem. I will present a preliminary version of the web site.

3. P1-A3

A STUDY OF DESIGNING SCIENCE TOYS INTO SCIENCE INSTRUCTION FOR 4TH GRADERS

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The major purpose of this study is to investigate the learning outcomes of designing science toys into science instruction for 4th graders. A quasi-experimental design was used with 4 classes students (N=122) at an elementary school in Taipei participated in this study. Two classes were assigned as the experimental group (N=61), and the others were the control group (N=61). Students in experimental group were given 5 weeks of designing science toys and competition activities into science instruction on the unit of "electric circuit", while the control group received traditional instruction. Three research instruments were used in this study include a science achievement test, a scientific attitudes scale, and a study questionnaire. The results were undergone by ANCOVA analysis. The results of this study include (1) the results of the science achievement test were that students in the experimental group got higher scores than students in the control group ($F= 8.397$, $p < .01$); (2) the results of the scientific attitudes scale were that students in the experimental group got higher scores than the control group did ($F= 5.182$, $p < .05$); (3) the learning feedbacks on the study questionnaire indicate that more than 90.2% of students in the experimental group had positive response on designing science toys in their science learning. Therefore it can be concluded that designing science toys & competition activities is effective for 4th graders' science learning in this study.

4. P1-A4

A STUDY OF PROJECT-BASED LEARNING ON THE UNIT OF ELECTRIC CIRCUIT FOR 4TH GRADERS

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The purpose of this study was to investigate the learning outcome of project-based learning on the unit of electric circuit for 4th graders. A quasi-experimental design was used in this study at an elementary school in New Taipei City. Students in experimental group (N=32) were given 6 weeks of project-based learning on the unit of "electric circuit", while the control group (N=32) received traditional instruction. Three research instruments were used in this study include learning achievements tests, scientific attitudes scales, and project-based learning checklists. The results were undergone by ANCOVA analysis. The major findings in this study were summarized as following: **1.** The learning achievements tests were analyzed by ANCOVA analysis. The results indicated that the students from the experimental group demonstrated significant improvement on the concept understanding than those from the control group did ($F= 101.584$, $p < .001$). **2.** The scientific attitudes scales were analyzed by ANCOVA analysis. The re-

sults indicated that the experimental group showed significant superiority over the control group on the scientific attitudes scales (F= 28.417, p < .001). **3.** During the stages of the project-based learning, the learning feedbacks from the experimental group indicate that most of students in the experimental group had positive response on doing science project-based learning. The researcher discovered that after experiencing the project-based learning the students from the experimental group have better learning outcome than those from the control group did. Therefore it can be concluded that project-based learning is effective for 4th graders in this study.

5. P1-A5

COMPARATIVE STUDY OF TRENDS AND PATTERNS WITHIN THE TEST CONTENT BETWEEN JUNIOR HIGH SCHOOL SCIENCE TEXTBOOKS AND EHIME PREFECTURE'S HIGH SCHOOL ENTRANCE EXAMINATION

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The purpose of this study was to investigate trends and patterns within the test content of Junior High School science textbooks. For this purpose, 511 questions were extracted and organized into a text database to analyze the method of questioning, as well as the content of the questions. Questions were grouped into the following formats: "short answer", "written answer", or "multiple choice answer". Their content was grouped into the following categories: "scientific terminology", "calculations", "explanation of natural phenomena", "explanation of reasoning", and "figures and graphs".The particular characteristics of the questions were examined, and the following two conclusions were drawn. (1) The "written answer" format and the "explanation of reasoning" question content appear less frequently in all fields. (2) The"explanation of natural phenomena", and"scientific terminology" questions accounted for 60 percent of all questions. These results were compared with the trends and patterns within the test content of Ehime Prefecture's High School Entrance Examination. As a result, it became clear that the questions of Junior High School science textbooks and Ehime Prefecture's High School Entrance Examination had similar trends and patterns.

6. P1-A6

MATHEMATICS PUZZLE AS AN EFFECTIVE ADVANCE ORGANIZER FOR MATHEMATICS LEARNING

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While mathematics teachers in Japan are tend to introduce literal expressions and numerical formula in advance before teaching main part of a certain series of lessons, many students in compulsory education level feel difficulty in this kind of treatment because of its foreignness. In order to remedy the situation and promote their effective learning, we tried to introduce a 'mathematics puzzle' as an advanced organizer at the very beginning class, because (1) effectiveness of the theory of Ausubel's advanced organizer has been already proved in the literature, and (2) 'mathematics puzzle' is believed to serve as a possible tool of effective 'starter' for any students' mathematics learning. In this study, an introduction by 'mathematical puzzles as the starter' was conducted for 5th and 6th graders' mathematics classes, in which total 100 students were participated. The findings from the comparison between pre- and post-test results indicated certain positive effects on their mathematical learning. Implications for improving 'methods of introduction' of elementary mathematics classes are also discussed.

7. P1-A7

INVENTIVE THINKING SKILLS AT AN EARLY AGE: COMPARISON BETWEEN MALAYSIA AND BRUNEI

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In preparing children for the knowledge based economy, learning outcomes in general need to focus on both technical or hard skills and general or soft skills. The former category includes a worker's facility with language or literacy, numeracy, and technology. The latter category, termed by some as 21st century skills includes abilities such as communications, creativity, information literacy, problem solving, and adaptability. The soft skills or 21st century skills are thus considered as important as the better understood trainable or hard skills in determining the eventual success of individuals operating in the knowledge economy. As one of the core subjects in the primary school curriculum, the outcomes of science curriculum must encompass both the acquisition of scientific knowledge and the attainment of the soft skills @ 21st century skills. The prime aim of this paper is to present findings from a cross sectional survey specifically designed to determine inventive thinking skills in science among some 400 primary students in Malaysia and Brunei and to determine whether there exist interaction in terms of inventive thinking skills accross country and gender. As one of the dimensions of 21st century skills, inventive thinking skills as measured in this study comprised of adaptability and managing complexity, self direction, curiosity, creativity, risk taking and higher order thinking and sound reasoning. Mapping of students' inventive thinking skills generated from this study provides pivotal baseline information for subsequent intervention strategies that should be undertaken within the context of primary science teaching and learning.

8. P1-A8

GRADE 10 STUDENTS' CONCEPTS ABOUT ATOMIC STRUCTURE

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The purpose of this research was to study 46 grade 10 students' con-

cepts about atomic structure in a special large school in Khon Kaen. The surveying used 10 opened concept survey and interview form. The concepts in these instruments included atom definition, atomic structure, characteristic of atom, constituents of atom and electrons surrounding. This paper presents only students' representation about atomic structure. The students were asked to explain and drawing of atomic structure. The data from concept survey and interview were analyzed and categorized the classifications' criterion was adapted from Tytler and Preston (2000). The result showed that most students (78.26 %) explained the atom similar to Dalton atomic model. The students did not identify which part of that model is atom. Moreover, some students showed Thomson and Bohr atomic model . Their explanations come from their prior knowledge about electricity. So, the students can not explain the atomic shape and structure.

9. P1-A9

DISCUSSION OF TEACHING METHODS ABOUT THE THEORY OF RELATIVITY IN PHYSICS IN BUSAN SCIENCE HIGH SCHOOL

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A new physics curriculum to teach general high school students in 2012 involve a theory of relativity. Physics teacher of Busan Science High School has taught a theory of relativity second-year grade students in modern physics class long since. Purpose of this study is to find an appropriate teaching methods about the theory of relativity in physics through surveys and in-depth discussion of Busan Science High School students and teachers. In addition, this study is could be more help and guidance in the new curriculum.

10. P1-A10

THE CHARACTERISTICS OF PERCEPTUAL CHANGE IN THE NATURE OF SCIENCE OF STUDENTS STUDYING ARTS THROUGH EXPLICIT INSTRUCTIONS

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The goal of science education lies in enabling students to have scientific knowledge to deal with the rapidly changing society and technology. For this, science education has put emphasis on the understanding of the nature of science. There have been many different opinions about what should be taught as the nature of science, but there haven't been any discussion of how it should be taught and who should be taught. The goal of this study is to explore the characteristics of perceptual change in the nature of science of students majoring in arts and apply the results to the scene of science education. According to the study, it is important to consider the results of interaction between learners' aptitude and teaching method. That is, teaching and learning expected to have highly educational effects should be conducted based on individual information on learners. In this study, we experimented with the students majoring in fine arts and music in a high school of arts, focusing on the fact that their tendency is quite different according to their major. We surveyed the perception of science among the students of each major, reflected the results in the explicit and reflective instruction on the nature of science, and analyzed how and why their perception of the nature of science has changed, focusing on conceptual ecology. This study is composed of three parts. In the first part, a survey was conducted to explore the nature of science, by studying the similarities between science and art reported by the third graders of a high school of arts in Gyeonggi-do. And the study analyzed what they think of as the similar aspects of science and art with focus on the extracts. As a result, they mentioned 'creative imaginary', 'correlation with technology', 'social and cultural relation', 'subjectivity', 'variability', and 'inquiring attitude'. The results are noticeable in that they are almost the same as the elements of the nature of science agreed by scientists. Specifically, in organizing classes, inquiring attitude can be used for teaching strategy in experimental inquiring context, and 'variability' can be used for teaching strategy in the context of scientific history. Through the study, we can propose a hypothesis that to help students understand modern perspective on the nature of science, teaching strategy in experimental inquiring context is more helpful for fine art students, who perceived 'inquiring attitude' most, and teaching strategy in the context of scientific history for music students, who perceived 'variability' most. In the second part, on the basis of the above hypothesis, teaching the nature of science to the first grade students explicitly, experimental inquiring strategy was applied to art students, and teaching strategy of scientific history to music students. To find out which elements of the nature of science have changed into view on modern philosophy of science, pre and post test on the nature of science(VOSTS) was conducted to the students. Consequently, it was found that experimental inquiring group showed meaningful change of views on 'tentative of scientific knowledge', 'scientific decisions' and 'theories of assumptions(hypotheses)', and scientific history group showed change of perspectives on 'theory-laden observation', 'tentative of scientific knowledge', and 'epistemological status of scientific knowledge'. Also, as a result of pre and post open test on the nature of science(VNOS-C), experimental inquiring group showed meaningful change of views on 'no single scientific method' and 'tentative of scientific knowledge', and scientific history group showed change of views on 'tentative of scientific knowledge' and 'social and cultural embeddedness of science'. This change is related to the specific contents of explicit instruction, and stressed point of each teaching strategy affects the elements of the nature of science. To find out specifically why views on the nature of science have changed, a case study was conducted focusing on the students who showed some change of views on the elements of the nature of science. 10 students were selected and had in-depth interview. In the process, it was intended to generally understand the factors affecting the elements of the nature of science positively and negatively, and their following effects. According to the analytic result, students understood just partially or incompletely 'no single scientific method' and 'social and cultural embeddedness of science', and had superficial understanding of 'the differences between theory and law' even when they had learned the differences. Also, as to 'the nature of creative imaginary', they perceived differently each inquiring level in which creativity get involved, according to their own definition of creativity, even though from view on modern philosophy of science, creativity should be perceived to be used in every inquiring level. In con-

clusion, this study suggests that by using experimental inquiring strategy and strategy of scientific history properly, it is possible to change students' viewpoints on the elements of the nature of science into views on modern philosophy of science. Through explicit instruction, we could find some positive conceptual change of the nature of science into view on modern philosophy of science in terms of both quantity and quality. This shows that the students studying arts are experiencing the constructivist conceptual change of the nature of science, and that conceptual ecology and learning strategy are involved in this process. Therefore, it is thought that this study offers an important implication in organizing science education on the nature of science.

11. P1-A11

THE IMPACT OF MULTIMODAL REPRESENTATION-BASED LESSON ON HIGH SCHOOL STUDENTS' UNDERSTANDING OF SCIENCE CONCEPT AND EMBEDDEDNESS OF MULTIMODAL REPRESENTATION IN WRITING

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The purpose of this study was to investigate the impact of multimodal representation-based lesson on high school students' understanding of science concept and embeddedness of multimodal representation in writing. The conclusion of this study was drawn that multimodal representation-based lesson had an effect on high school students' understanding of science concept and embeddedness of multimodal representation.

12. P1-A12

A STUDY OF USING NEWSPAPER IN EDUCATION INTO SCIENCE LEARNING FOR 6TH GRADERS

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The purpose of this study was to investigate the learning outcome of using Newspaper in Education into science learning for 6th graders. A quasi-experimental design with a single group was used in this study at an elementary school in Taoyuan City. Students in experimental group (N=33) were given 12 weeks of instructional strategies on Newspaper in Education. Three research instruments were used in this study include attitudes toward Newspaper in Education (29items, Cronbach α=.90), attitudes toward science reading (15items, Cronbach α=.93), and scientific attitudes scales (27items, Cronbach α =.92). The results were undergone by t-test analysis. The major findings of this study include (1) the outcomes of attitudes toward Newspaper in Education indicate that students did better on their post than pre-test ($t = 6.110$, $p < .001$); (2) the outcomes of attitudes toward science reading indicate that students did better on their post than pre-test ($t = 9.264$, $p < .001$); (3) the outcomes of scientific attitudes scales indicate that students did better on their post than pre-test ($t = 7.327$, $p < .001$). Therefore, it can be concluded that using Newspaper in Education did improve 6th graders in their science learning.

13. P1-A13

PROMOTING 5TH GRADE STUDENTS' SCIENTIFIC CONCEPT CONSTRUCTION, REASONING AND INQUIRY THROUGH SCIENTIFIC INQUIRY INSTRUCTION

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The purpose of this study is to explore the effectiveness of scientific inquiry instruction, either with or without an emphasis of both deductive and inductive scientific reasoning, on students’ conceptual construction, scientific reasoning and scientific inquiry. This study is a quasi-experimental design. Four intact classes of 115 fifth-grade students participated in the study. Students were randomly assigned to two different groups, one that received simply inquiry learning and another that received inquiry learning with emphasis on scientific reasoning. There was a total of nine class periods in which students received instruction on three topics. Both qualitative and quantitative data were collected in the study. All students took the Science Concept Construction Test, Scientific Concept Dependent Reasoning Test and Content Dependent Inquiry Test before, immediately after, and two months after. In addition, students’ learning processes were collected during their learning. Results indicated that the experimental group outperformed the control group on the Science Concept Construction Test, Scientific Concept Dependent Reasoning Test and Content Dependent Inquiry Test. Moreover, the qualitative data also showed evidence that the experimental group outperformed the control group in their use of correct conceptions and level of scientific concept dependent reasoning in both their generation of hypothesis and making conclusions.

14. P1-A14

EXPERIMENTAL STUDIES AIMED AT TEACHING NEW COURSE OF STUDY IN RESPONSE TO THE HIGH SCHOOL BIOLOGY IN JAPAN

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This study is one case developed a leadership training program aimed at experiments. The result can be obtained from the program high remarks to the students who participated, was sent to school actually some participants, DNA extraction was performed, and received favorable. In addition, the experimental work of the leader in high school classes, PCR could be carried out effectively for gene determination. The goal of this study is to illustrate the effect of this program that high school students could make communicate with others in molecular biology experiments. There are new curriculum

guidelines in Japan. Because, the Courses of Study for elementary school education and lower secondary school education were revised in 2008 and the Courses of Study for high school education was in 2009. As the New Curriculum Guidelines were revised to add gene regulation in the junior high school curriculum, practical content such as DNA could be covered in our program. Our program was effective in helping students appreciate the inquiring maids and attitudes of scientist. Effects on student curiosity were seen, and this program was also effective in cultivating skills and attitudes to spontaneously tackle progressively advanced content. In Japan, the revised high school science curriculum guidelines were based on the report of the Central Council for Education in January 2008, "Ⅰ Biology" and "Ⅱ living" were reorganized "biological basis" and "Biology". The contents of the new biology in particular "genetic information and protein synthesis" of the current elective "Ⅱ living" to "biological basis", as the result, now many high school students take an introduction. But in high school, "genetically modified" or "PCR determination for gene" experiments, as is required to be carried out in more schools was. In junior and senior high schools when the DNA for the first time in the classroom to support measures will be made easier with the teachers thought DNA tests on the intake. As such measures, high school students to cultivate leadership experiment, activation was assumed to be obtained by letting the working class as an assistant teacher. Additionally, this study was conducted with the assistance of the SPP(Science Partnership Program), sponsored by JST(Japan Science and Technology Agency).

15. P1-A15

EDUCATIONAL EXPERIMENT UNDER THE MICROGRAVITY CONDITION IN A PARABOLIC FLIGHT OF MU-300

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Microgravity condition can be created in a cabin of an airplane for 20 seconds while the plane is in a parabolic flight. Since microgravity phenomena is expected helpful in teaching the basics of physics such as "difference between mass and weight" and "energy transfer between kinetic energy and potential energy", to junior high school students, a few kinds of video clips of the phenomena were made using a small jet MU-300, which was operated by Diamond Air Service Inc. In order to demonstrate the difference between mass and weight, the movement of two substances with different mass on which the same magnitude of force was applied was compared. As for the energy transfer between kinetic energy and potential energy, the movement of a pendulum was compared before and after the microgravity was established. The devices used in the experiments were easy and simple so that the students can grasp the phenomena visibly and reproduce the similar experiment on ground by themselves. The video recorded in the plane was edited and prepared to be compared with the phenomena that can be observed under 1G condition on the ground.

16. P1-A16

CRITICAL THINKING AND LEARNING ACHIEVEMENT BY THE OPEN INQUIRY LEARNING ACTIVITIES

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To student of thinking and devalope learning achievement by constructivism through the thinking process and the learning activities, open inquiry learning approached and conventional learning. The purposes of this study were to compared means of critical thinking, learning achievement, and find the correlation between problem solving ability and learning achievement. Who comprised the total population was 250 of Mattayomsuksa 4 students in Wangsammowitayakran School under the Udonthane Education Mattayomsuksa Service Area 20 in Wangsammo District, Udonthane Province. The samples were randomly classified into two groups, 49 students for an experimental group and 48 students for a control group. Their ability of problem solving and learning achievement were measured by using the tests of content-specific knowledge, Critical thinking, scientific process skills, and scientific attitude. The data were analyzed by computing of arithmetic mean and standard deviation, and a comparative analysis of t-test. The finding showed that both groups had a significant difference in Critical thinking, learning achievement, and scientific process skills, but their scientific attitude was not difference significantly. The correlation analysis showed that the experimental group had a significance of positive correlation between their Critical thinking ability, learning achievement, and scientific process skills.

17. P1-A17

A NARRATIVE INQUIRY OF AN EXEMPLARY SCIENCE TEACHER'S PROFESSIONAL GROWTH

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The major purpose of this narrative inquiry is to explore an exemplary science teacher's professional growth. Narrative inquiry research method (Clandinin and Connelly, 2000) was used in this study. Subject of this study is a retired elementary science teacher who has continuously spread his influence over many other science teachers and parents for many years. Narrative inquiry data from interviews, workshop participations, and observations were collected and analyzed. Major findings were include：(1) the main factor that influenced teacher's professional growth was teacher's belief about science teaching, (2) prior experience from supportive profession group enhance this exemplary science teacher's motivation and action in building up his own profession group and supporting science education, (3) activities from workshops by the supportive profession group did contribute a lot for the science teacher professional growth.

18. P1-A18

ITEM ANALYSIS OF TEST OF USING SCIENTIFIC EVIDENCE FOR PRE-SERVICE ELEMENTARY SCHOOL TEACHERS IN TAIWAN

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The purpose of this study was to develop a Test of Using Scientific Evidence (TUSE) to realize the abilities of using scientific evidence for pre-service elementary school teachers in Taiwan. Based on the PISA 2009 assessment framework, the TUSE contained 3 cognitive and 4 content domains. The cognitive domains were abilities of "interpreting scientific evidence and making and communicating conclusions", "identifying the assumptions, evidence and reasoning behind conclusions", and "reflecting on the societal implications of science and technological developments". The content domains were physical systems, living systems, earth and space systems, and technology systems, respectively. The test subjects were pre-service elementary school teachers. Samples were randomly drawn from a national university of education in Taipei, Taiwan by using a cluster sampling method. Several techniques of item analysis, such as item difficulty index, item discrimination index and option characteristic curve (OCC) by using kernel smoothing approaches to nonparametric item characteristic curve estimation, were demonstrated in the study. Results of the study could provide the significant evidences of quality assurance for the TUSE.

19. P1-A19

MIDDLE SCHOOL STUDENTS' KNOWLEDGE STATE ANALYSIS ABOUT LIGHT

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Although there are various materials in instructing the students in the field of the school, the evaluation has been commonly used in evaluating the level of the learning. However, in the case of most evaluation, we completely cannot know about the connection between questions that is a detailed evaluation about the concept of the learning. we just know the information of the whole grade. In the existing evaluation, mostly informations of the whole grade is used and we completely cannot know about the connection between questions about the knowledge of the learning. That is, we have to take note that the evaluation of two students who get the same grade was different. The knowledge of science has the hierarchy, and the super knowledge is laid on the fundamental one. Therefore, we can develop curriculum suited the area of expertise according to the hierarchy of knowledge. The hierarchy in the knowledge of science is of great importance in teaching the students. If we accurately measure their problems in the hierarchy of knowledge and make up for it in science education, it will be efficient learning. In addition, it will be efficient learning when we diagnose the state of student's prior knowledge in advance and plan the class. There are the theory of knowledge space that is studied as the method of analyzing evaluation results from students. This theory is based on the hierarchy of knowledge that is claimed by Jean-Paul Doignon and Jean-Claude Falmagne. Therefore, it is appropriate to strongly hierarchial subjects such as mathematics and science. When analyzing the evaluation results, we can measure student's hierarchy whether choose a right answer or not, not using a number of student's grade. In this study, we developed 15 evaluation questions about light targeted at the gifted and the average in the Middle school. After appling to the students, we analyzed it using the theory of knowledge space. From this, we also analyzed the knowledge state by schematizing the hierarchial concept of light. Through this, we compared the concept of light by analyzing the individual or grouped informations. As a results, we found that either of them have the different knowledge structure and have to be evaluated in different ways. In other words, through the analyzing result of hierarchy using the theory of knowledge space, we could see many significant results that was not found in a existing arithmetical mean.

20. P1-A20

THE SPECIALIZATION OF MATHEMATICS AND SCIENCE TEXTBOOK APPROVAL SYSTEM IN KOREA

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Today middle school math and science textbook system in Korea is authorization. This system has been criticized for development and approval of similar textbooks. According to 2010~11 math and science textbook committee members survey and research, this system has mainly three problems-inconsistency between primary and secondary textbook review stages, a lack of specialization about creativity evaluation, most of textbook review committee members are subject content or educational experts. Many people have requested for variety and interesting math and science textbooks. And authorization system is going to be changed, so we have to get ready for more specialized textbook review system. KOFAC (Korea Foundation for the Advancement of Science & Creativity) has pushed ahead with a reform of math and science textbook authorization system since 2010. KOFAC has put into practice new strategies for reviewing of good math and science textbook. First, primary panel members write 'primary result report summary' for enhancing consistency between review stages. Second, many experts researched criteria and examples about scientific creativity and the result was provided textbook committee as a reference. Every committee members participate in reviewing about creativity. Third, we appointed with textbook committee members from variety of academic and industrial organizations, science research institutes etc. KOFAC adopted these strategies at middle school math and science textbook authorization system in 2010~11 and it worked pretty well.

21. P1-A21

DIFFICULTIES ENCOUNTERED IN UNDERSTANDING ACID-BASE CHEMISTRY

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The present study reports findings from the investigation of students' understandings of acid-base chemistry. Previous research has consistently indicated that many high school students had serious difficulty in understanding this concept. A two-tier multiple choice diagnostic test was administered to 126 students in grade 11 who studied at small rural schools located in four Northeastern provinces of Thailand and had never received instruction in acid-base chemistry. Students' responses were assessed and grouped into five different levels of students' understanding: sound understanding, partial understanding, partial understanding with specific alternative conception, specific alternative conception, and no understanding. The data indicated that most respondents hold alternative conceptions on several concepts: acid-base theory, dissociation of weak acids, weak bases, and water. Particularly acid-base theory, the students seemed to experience considerable difficulty in understanding. The findings provide evidence for teachers to help the students grasp acid-base chemistry which is a fundamental concept in learning further advanced concepts.

22. P1-A22

ASSESSMENT OF DEVELOPMENT OF CHEMISTRY EPISTEMIC STYLE OF HIGH SCHOOL STUDENTS

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In the present study, the researcher has built a model to assess the chemistry epistemic style of high school students. In addition, the researcher has developed assessment tools based on the analysis of epistemic styles of the four epistemic fields of organic chemicals, inorganic substances, chemical reaction, and electrolyte solution. The internal consistency coefficient a of the assessment tools for each epistemic field is greater than 0.85. This research takes part of senior high students from twelve schools in Beijing, Nanjing, and Weifang as its sample, and evaluates their development levels of chemistry epistemic style to verify the formation model of chemistry epistemic style. The results show that: (1) The current development of epistemic styles for each epistemic field. **a.** After learning mandatory modules, students have been found to possess low levels of epistemic style on organic chemicals. The epistemic style category of most students on organic chemicals is at the macro-isolated level and they have not established completely the epistemic perspective of organic chemicals. After learning optional modules, students have developed their epistemic style on organic chemicals. The epistemic style category of most students on organic chemicals is at the sub-micro-systematic level and basically, they have established two important epistemic perspectives, namely, composition/structure and property. However, the students have not established the epistemic perspective of "transformation and synthesis of organic chemicals." **b.** After learning mandatory module 1, students have acquired the medium level of epistemic style on inorganic substances and have established two most basic epistemic perspectives in the epistemic field of inorganic substances, namely, composition and properties. Furthermore, the students have formed two Level II epistemic perspectives, i.e., physical property and chemical property. Their epistemic style is categorized at the macro-isolated level. After learning the optional modules, students have built a new epistemic perspective based on the original perspectives of origin of inorganic substances (preparation) and showed comprehension of the property of inorganic matters based on elements and the epistemic style category of macro-systematic. However, the students have not established the epistemic perspective of "application of inorganic substances." **c.** After learning mandatory modules, students have been found to possess low level of epistemic style on chemical reaction and have assimilated only one epistemic perspective, i.e., "material change" on chemical reaction. Their epistemic style category belongs to the level of "macro-quantitative-isolated." After learning optional modules, most students have established the two basic epistemic perspectives of material change and energy change and have formed the epistemic style category of macro-systematic. **d.** After learning mandatory module 1, students demonstrated low levels of epistemic style on electrolyte solution and have established the two basic epistemic styles on composition of single solution and reaction between solutions. Nevertheless, their epistemic style category is at the macro level. After learning optional modules, students have shown comprehension of the composition and property of solution by the epistemic style category of "micro-systematic" and the reaction between electrolyte solutions by the epistemic style category of "micro-dynamic." However, they have not achieved possession of the epistemic angle of "application." (2) Only when the level of chemistry epistemic style reflected by the teaching book is above other versions of teaching books, and only when the teaching book describes the definite epistemic path and requests students to experience the process personally can the teaching book become the major factor that will affect the development of epistemic style of high school students. Hence, the present study will offer guidance to the organization as well as in the selection of teaching materials, compilation of teaching books, teaching design, and implementation.

23. P1-A23

SCREENING GIFTED STUDENTS IN SCIENCE THROUGH OBSERVATION IN THE CLASSROOM

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In Korea, education for the gifted students in science has been done nationwide since the spring of 2002. Twenty five Institutes under University supervision were established since then, and special classes for the gifted students were assembled in several primary and junior high schools under the supervision of Provincial Office of Education. Instead of selecting students through conventional stepwise knowledge-based tests, Korean Government advised to select students by screening through educational process in the class. Here we present s few guidelines of what to look for during screening to help the teachers involved in gifted education. In general, gifted students possess several virtues including intelligence, perseverance, originality, creativity, and imagination. However, to excel in science there are more characteristics desired. Basic knowledge, tenacity, hardship, lifetime interests and passion for science are amon them. The most basic process in science is to observe. Students who know what to observe and how to observe are in more favorable position. Darwin and McClinctock were not able to do their achievement without their keen observing ability. Strong basic knowledge is preferable for not wasting efforts on useless things and saving time. Original and creative thinking, and vivid imagination will be a big plus when encountered with difficult problems. Enduring hardship and patience to repeat the same experiments are a great advantage in scientific research. The analytical skill to scrutinize and interpretate the experimental data are crucial. We will discuss how and why these properties are important in judging students for their prospect by citing the instances of great scientists in the history. Finally, we also present two tables of checklists which may be helpful in judging students for their scientific possibility during class.

24. P1-A24

DEVELOPMENT OF TEACHING MATERIALS FOR UNDERACHIEVERS IN MIDDLE SCHOOL SCIENCE

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In this study, definitions of academic underachievement in general as well as in science education were identified and the reasons why the underachievers show significant discrepancies between the levels of performance that could be expected and their actual academic achievement in science education were explored. In accordance to the reasons of these discrepancies, the teaching materials for underachievers in middle school science based on Korean science curriculum were developed. Science concepts dealt with this teaching material were states of matter, evaporation and condensation, relationship between thermal energy and molecular motion, Boyle's Law and Charles' Law.

- **Poster Exhibition 1-B**
- **Date: Wednesday, October 26, 2011**
- **Time: 14:20 ~ 15:20**
- **Room: Main Room**

25. P1-B1

DEVELOPING WEB-BASED VIRTUAL GEOLOGICAL FIELD TRIP USING FLASH PANORAMA AND EXPLORING ITS UTILIZATION

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In school science class, actual geological field trips tend to be restricted due to a number of problems including travel distance, cost, safety, and so on. Therefore, alternative way should be sought to provide students with the benefits of actual field trip. The purpose of this study is to develop web-based virtual field trip (VFT) using flash panorama, and to explore a variety of ways to utilize the VFT. The characteristics of developed VFT are as follows: it provides virtual space for secondary school students to learn about geology and topography; students can access contents in a non-sequential order by virtue of web-based system, and students can control learning pace according to their ability; it is possible to investigate the same field site repeatedly, not limited by time and space; it presents differentiated worksheets for different school grade; it provides diverse complementary web contents connected to flash panorama, e. g., close-up features, video-clips, thin sections, inquiry questions, and explanations of outcrops. This study also proposed instructional models and several ways to utilize VFT in school science class and extra-school curricular as well.

26. P1-B2

THE IMPACTS ON SCIENCE LEARNING USING A MICROCOMPUTER-BASED LABORATORIES INSTRUCTION

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The purpose of this research is to study the effects of a microcomputer-based laboratories instruction (MBLs) on students' problem solving. The study objects are five grade students of elementary school. Qualitative research shows that the two groups (experimental group - with MBLs, and the control group - not using MBLs), the experimental group can enhance students' problem solving ability.

27. P1-B3

SIXTH GRADERS' LEARNING OF ANIMAL CLASSIFICATION WITH INTERNET RESOURCES: HIGHER ACHIEVERS VS LOWER ACHIEVERS

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This paper discusses the learning of animal classification with Internet resources by the students in two 6th grade classes, one being higher achieving and the other being lower achieving. This study tries to find out: (1) students' conception of animal classification and the criteria used to classify animals, (2) student learning of animal classification with Internet resources and (3) the differences (if there is any) in learning of animal classification with Internet resources by higher- and lower-achieving students. The two classes involved in this study are taught the same topic "Animal classification" by the same teachers using the same teaching design in two separate lessons. The teaching design is created by the teacher based on a framework of Resource-Based e-Learning Environments (RBeLEs) developed by the research team in an earlier stage of the project. The RBeLEs framework aims to support teachers in creating e-learning environments with Internet resources more effectively by helping them to think about and design the four framework components – (1) creation of contexts, (2) selection of resources, (3) use of tools, and (4) adoption of scaffolds. Concept mapping is employed as an assessment tool to find out student conception of animal classification and from which the criteria

that students used to classify animals are revealed. Each student is required to draw a concept map before and after the lesson. Qualitative analyses of the pre-lesson concept maps show that students mostly used criteria of habitat and locomotion to classify animals and that students' conception of animal classification is incomplete and inaccurate. Comparisons of the concept maps collected before and after the lessons are made so that changes in students' conception and the criteria they applied can be measured. Besides, a modified scoring system proposed by Novak and Gowin (1984) has been adopted for evaluating student learning of animal classification quantitatively. Since relationships and cross links does not exist in the concept maps drawn by the students, the scoring focuses on the hierarchy (5 points for each valid hierarchy) and examples (1 point for each valid example) displayed. A total score is given to each concept map by adding up the two scores. The total scores as well as the individual of the pre- and post-lesson concept maps are compared using paired samples t-test. Concept map scores for the two classes are also compared to identify any differences in learning by different achieving students. Moreover, face-to-face in-depth interviews with the focus group students from each class have been carried out after the lessons to understand how learning of animal classification with Internet resources within the RBeLEs takes place.

28. P1-B4

THE IMPACT OF ON-LINE INQUIRY LEARNING ON STUDENTS COMPETENCIES IN IDENTIFYING SCIENTIFIC QUESTION AND SCIENTIFIC EXPLANATION ABILITY

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This study was to explore the difference between scaffolding and non-scaffolding on-line inquiry learning on students' concept construction, scientific explanations and competencies in identifying scientific question. A total of 123 7th graders recruited from four average-achievement classes of a middle school. Sixty three of them received scaffolding on-line learning for three units, and the other sixty students received non-scaffolding on-line learning for three units as well. The content-dependent conception Test (CDCT), Scientific Reasoning Test (SRT) and content-dependent PISA Test (CDPISA) were administered to all students before, directly after and after the eighth week of learning. The results indicated that scaffolding group's students' outperform than non-scaffolding group on CDCT, SRT and CDPISA and reach statistical significant difference level except SRT. The students' web learning result indicated that scaffolding group outperform than no-scaffolding group regardless identifying scientific question, identifying variables, formulate hypothesis and scientific explanation. Specifically, the detailed qualitative analyses of identifying scientific questions and scientific explanation all indicated that scaffolding group performed at higher levels of identifying scientific question and scientific explanations than to the non-scaffolding group.

29. P1-B5

DEVELOPMENT OF AN ECO-FRIENDLY ANIMATION-BASED COURSEWARE USING MULTI-MEDIA FOR PRIMARY AND SECONDARY SCHOOL STUDENTS IN ENVIRONMENTAL EDUCATION

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The purpose of this study was developing the animation-based learning courseware using multimedia for primary and secondary school students in environmental education. The courseware focused on helping them understand environmental concepts, motivating them to learn environmental topics and making the most of it. The courseware was web-based and consisted of animations, animated-databases and animation games. Animations were made on the basis of stories and voices. Databases consisted of photos and video clips. After examining educational contents by experts on environmental education, learning concepts and expression pattern were determined according to student-level, which are primary, junior high and high school students. The topic covered by "Alien plants and animals". Sub-topics were meaning of alien species and naturalized species, kinds of alien species, ecological effects of alien species, introduction of alien species, and management of alien species. Using this courseware in both formal and informal classes, primary and secondary school students can be encouraged to get eco-friendly mind as well as promoted to understand basic environmental concepts.

30. P1-B6

VISUALIZATION MATERIALS OF GEOMETRICAL OBJECT IN JUNIOR HIGH SCHOOL MATHEMATICS: USE OF A 3D DYNAMIC GEOMETRY SOFTWARE

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In geometry learning, students develop their thinking from intuitive to demonstrative ones. Also current (Japanese) curriculum on geometry education is organized from intuitive to demonstrative ones. Therefore, mathematics educators need to deal with intuition and deduction cooperatively in teaching geometry. Some students, however, face difficulty in learning demonstrative geometry. Thus, it is expected that students' spatial recognition could be enhanced by presenting properties of figures intuitively (that is, mathematical visualization of geometrical object). In this study a 3D dynamic geometry software Cabri3D was used as the means of mathematical visualization, because some of previous works have revealed that visualization could help students to grasp essential nature of the problems and understand nature of mathematics correctly. The present paper reported developing process of teaching materials, which foster students to think

on properties of composed figures, topological properties, affine properties and Euclidean properties in a Cabri3D environment, integrally. The results indicated that a use of Cabri3D was successful in the following the merits of three points: (1) Concrete examinations, numerical solution, approximate value and inductive method could be introduced in the mathematics class, (2) logical abilities to analyze geometrical figures among the students were enhanced, and (3) by encountering impressive experiences of geometry, students realized that learning space figure was fun and useful. The findings reconfirm that mathematical visualization by such software promotes students' deeper understanding of special recognition. The authors convince that this visualization can contribute significantly to improve teaching of geometry and propose a new method of teaching in geometry education in Japan.

31. P1-B7

INTEGRATING TAIWAN INDIGENOUS CULTURE INTO ELEMENTARY SCIENCE TEACHING

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The aim of this study was to investigate how a research teacher integrated Paiwan Indigenous Culture into science instruction through cooperation with a school teacher. The study was conducted in an elementary school in Pingtung. Researchers sought Paiwan Indigenous Culture and Paiwan science wisdom integrating it into learning materials. Qualitative research method was used for this study. The researchers, as a main research instrument, entered experienced science expert teacher's classroom to collect data. Data were collected by classroom observations, interviews, and document analysis. Results found that for designing a Paiwan Indigenous Culture integrating course, we needed to seek the materials from the culture and experiences in their life, and we had to consider students' prior experience, so that we can encourage students' interest in learning efficiently. Teachers had to know the Paiwan Indigenous Culture so that they can combine culture with science concept. Besides, by the course of integrating Paiwan Indigenous Culture into science instruction, the research teacher can promote his multi-cultural quality, teaching and course designing ability. The results can be used as a reference for indigenous people science education teacher training in the future. The research findings suggest that science teacher education program should offer the courses, such as "indigenous scientific education teaching curriculum" and "multi-cultures and scientific curriculum". Hoping that the results could provide a way to rethink how to build the indigenous students' confidence in science, and it could also recommend further research how to integrate traditional cultures into the development of science.

32. P1-B8

THE EFFECTS OF S-BEL PROGRAM ON MIDDLE SCHOOL STUDENTS' AWARENESS ABOUT SCIENTIFIC LITERACY AND ATTITUDES CHANGES

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The science museum shows the progress of science technology and its historical footsteps providing a vision of future science technology to the people living in the present society of science technology by offering them to scientific knowledge and science-related information. It is also a field of education which helps people to recognize the relationship of the society and science technology, which builds science-culture of all people. The exhibits in the Science Centers are by themselves fairly influential to science education. It is in a complementary relationship with the school subject and provides opportunities for an alternative kind of learning that cannot be easily realized in the boundaries of the schools. In order to successfully integrate the regular curriculum at school and the activities outside, it is the most effective to interrelate the regular curriculum and the outside activities in teaching the students. In consideration of the above, the purpose of this study is to find out the implication of the educational activities in the Science Centers on science education by examining the changes and awareness on science in a science-technology-societal perspective held by middle school students in a case study of S-BEL (Scientorium Based Exploration Learning) implemented by Gwacheon National Science Center , which provides a proper educational content reflecting the school curriculum and provision of information on the facility for out-of-school learning activities.

33. P1-B9

DEVELOPMENT OF SCIENTIFIC CREATIVITY BEHAVIORAL CHARACTERISTICS CHECKLIST BASED ON ANALYSIS ON PHYSICISTS' BEHAVIOR IN GROWTH PERIOD

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What behavioral characteristics do creative scientists have? If we have an answer to this question, then this information can be used to guide students to become the creative scientists or to select potentially creative students in science. The purpose of this study is to develop scientific creativity behavioral characteristics checklist focusing on cases through analysis on prominent physicists' growth period by historical approach. To do this, six prominent physicists were selected to be analyzed: Isaac Newton, Michael Faraday, James Clerk Maxwell, Albert Einstein, Werner Karl Heisenberg, Richard Phillips Feynman. Their behavioral characteristics related to scientific creativity were extracted by reviewing and analyzing the literature including autobiography, biography, history of science, letter, etc. during the period by their age of 21. As a result, 30 behavioral characteristics related to scientific creativity could be extracted. And these characteristics were categorized into 6 main-categories and 12 sub-categories. Using this, we developed checklist. To find out whether this checklist is available in schools, the developed checklist was offered to in-service program in which 350 science teachers participated. In the in-service program, teachers used the checklist to analyze behavioral characteristics of the science high school students' self-introduction. Through this application, we believe that the developed checklist can be used as the preliminary data for selecting and recommending students with scientific creative potential. Besides, it can be used as a guide for students to improve their scientific creative potential.

34. P1-B10

DEVELOPING SCIENCE LEARNING ACTIVITIES CONSIDERING CHARACTERISTICS OF GIFTED LEARNER

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Learning activities dealing with scientific contents have been developed in many institutions for gifted learner. When science learning programs are developed, the characteristics of gifted students ought to be considered. In this research, our goal is to develop science learning activities for meeting the needs of the gifted, with the question of "Does life exist elsewhere in the universe?" Before designing the learning activities, we first extract the characteristics of the Gifted in research literature. After sampling, we design the activities based on the characteristics. The activities are applied to five Year 9(14- to 15-year-old) gifted students. Short questionnaires and interviews to verify achievement of our goal were conducted. As a result of the activities, students gain very useful experiences of representing their mental models of abstract concepts, integration between their concepts and scientific concepts, forming scientific models, cultivating creativity and critical thinking, and employing meta-cognition.

35. P1-B11

IMPROVEMENT OF STUDENTS' PROBLEM FINDING AND HYPOTHESIS GENERATING ABILITY: GIFTED SCIENCE EDUCATION PROGRAM UTILIZING DARWIN'S THEORY OF EVOLUTION

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In the process of establishing the theory of evolution, Darwin discovered problems based on various observations during the voyage of Beagle and acquired insights from reading the Population theory by T. Malthus. Darwin's scientific thinking ability can be effective teaching and learning topics for gifted science education programs, The study aims to develop a science gifted education program utilizing Darwin's scientific thinking ability shown in the theory of evolution and analyze students' changes in scientific thinking ability before and after the program implementation. For the program development, first, the characteristics of Darwin's scientific thinking ability in the process of establishing the theory of evolution were investigated and extracted the major elements of inquiry. Second, the science gifted education programs was developed by applying the inquiry elements from the Darwin's theory of evolution. The program was implemented with 60 students of 7th and 8th graders who attend the science gifted education center affiliated with universities during January and March 2011. Darwin's scientific thinking ability shown in the theory of evolution was classified into induction, deduction and abduction. The elements of inquiry extracted from the Darwin's scientific thinking were making observation, puzzling observation, proposing causal questions, generating hypothesis, drawing inference, designing experiment, gathering and analyzing data, drawing conclusions, and making generalization. With applying these elements, the program was developed with four phases: 1st - problem finding; 2nd - hypothesis generating; 3rd - hypothesis testing; and 4rh - problem solving. After implementation, students' changes in scientific thinking ability were measured. The findings from the study are as follows: First, students' abilities of problem finding and hypothesis generating were significantly ($p<.05$) increased. Second, students' conceptual understandings of evolution were improved.

36. P1-B12

THE EFFECT OF SCAFFOLDING INSTRUCTION ON IMPROVING ARGUMENTATION SKILLS OF THE SIXTH GRADE STUDENTS IN SOCIOSCIENTIFIC CONTEXTS

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The purpose of the study aimed at improving the argumentation skills of the sixth grade students in socioscientific contexts through scaffolding instruction. The study adopted quasi-experimental design. One experimental group (N=32) received the instruction with oral and written scaffolding for argumentation. The other experimental group (N=33) received the instruction with only oral scaffolding for argumentation. The control group (N=30) received traditional instruction. Each group was subsequently administered three argument questionnaires which involved different socioscientific contexts respectively before and after the instruction. The teaching intervention for each group spanned six weeks and one hour a week. The results revealed that the effect of teaching methods on students' performance of argumentation is not related to the socioscientific contexts. The two experimental groups significantly outperformed the control group in making arguments, counterarguments, supplementary warrants and rebuttals ($p<.05$). There was no statistically significant difference between the two experimental groups in formulating argumentation ($p>.05$).

37. P1-B13

BY CONSTRUCTION OF CONCEPT MAP TO INVESTIGATE WHAT IS THE NECESSARY LITERACY OF GRADE 3 TO 12 STUDENTS IN NANO-SCIENCE

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Nano-technology hasbeen an influential technology in contemporary society. From the position of education, modern civil should have the qualities about nanotechnology, so what is the necessary literacy of students in nano-Science becomes an important issue in science education. The Administration of Education and National Science council in Taiwanconcern this issue, and many educational projects tried to develop science curriculum to improve the civil literacy of nano-science, especially the grade 3-12 students. The purpose of this study was to explore the necessary literacy of student related to nano-science. The first, we tried to construct a concept map of nano-science. Then, based on the constructed nano-science concept map to investigate what literacy isprimary and secondary students necessary in modern society. The research method included Delphi technique and interview. The first phase, we interviews with six experts, then protocol analysis was conducted by three researchers, so that we can obtain high reliability of coding, then six Nano-science concept maps were co-drawn by each expert and researcher. Finally, through focus groups discussion, an agreement of integrated nano-science concept map was obtained. In the second phase, we adopted the Delphi technique to investigate basic literacy of nano-science for grade 3-12 students. The instrument was self-designed "students nano-science literacy questionnaire". The questionnaire included 5 dimensions and 28 items. The consultants included three categories of experts: scientist, science educator and science teacher. Each category involved 8 consultants. By two round of review, the agreement of civil nano-science literacy wasobtained. The contents of this literacy involved five dimensions and 22 items. The findings will support the nano-science curriculum designer to develop suitable curriculum and teaching material in Taiwan.

38. P1-B14

SOCIOSCIENTIFIC ISSUES AS AN INSTRUCTIONAL TOOL FOR CREATIVITY AND CHARACTER (CREACTER) EDUCATION

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This study explored to what extent Korean science teachers perceived socioscientific issues (SSI) as an effective instructional tool for creativity and character (CreActer) education, which was recently announced as a main goal of Korean National Science Curriculum 2009. The guiding research questions were as follows. (1) How do science teachers conceptualize the relationship between creativity and character in the context of science classes? (2) What do science teachers think about the possibility of CreActer education through SSI in science classrooms? Thirty science teachers in secondary schools, located in Seoul and Gyeonggi Province, participated in individual interviews (each lasted 20-90 minutes). Inductive analysis methods were employed to find emergent patterns, and we adapted researcher triangulation to ensure the credibility of our analysis. In results, the teachers' perceptions on CreActer education and SSI for CreActer education were categorized into four profiles (Profile A-Profile D). Eleven teachers in Profile A thought that creativity was positively correlated with character education because their understanding of creativity and character embraced very broad range of elements. They believed that creativity could include both cognitive (e.g. divergent thinking, convergent thinking, problem solving, knowledge, etc.) and affective elements (e.g. curiosity/interest, flow, open-mindedness, independency, etc.). Character could also include interpersonal virtue (e.g. care-forgiveness, appointment, responsibility, honesty, etc.), and judgment for creative character (e.g. moral sensitivity, moral judgment, moral motivation, moral behavior, etc.). In addition, they mentioned that addressing SSI in the science classes would content to cover those elements of CreActer education. Six teachers in Profile B mentioned similar elements of creativity and character of Profile A, but reported that, in their experience, creativity was often inversely correlated with character. However, they responded that addressing SSI would be a good way to integrate creativity and character in the science classes. Ten teachers in Profile C believed there was no relationship between creativity and character, but took a positive stance on CreActer education through SSI. Unlike Profile A and Profile B, they tended to regard character as only interpersonal virtue. And three teachers in Profile D had narrow perspectives on CreActer education. Not only did they think creativity had no relationship with character but also disagreed that CreActer education would be activated by addressing SSI in science classrooms. The results imply that SSI could be used as an effective instructional tool for CreActer education, but this can be possible when science teachers expand their view on CreActer education.

39. P1-B15

MEDIA INFLUENCE ON KOREAN MIDDLE SCHOOL STUDENTS' DECISION-MAKING OF NUCLEAR POWER GENERATION ISSUES

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This study explored in what ways Korean middle school students dealt with media information when making a decision on support for Korean nuclear power generation issues. Forty students participated in individual interviews lasting 15-20 minutes. We used the recent crisis at the Fukushima Daiichi nuclear plant as the interview context because most of Korean students were exposed to extensive and various information about the event through the mass-media. Inductive analysis methods were employed to find emergent patterns of students' decision-making and their influence by the media, and we adapted researcher triangulation to ensure the credibility of our analysis. The participating students reported exposure to a wide range of media information on the Japan nuclear crisis, including causes of the accident, effects (e.g. human victims, economic loss, etc.), and global reaction (dispatching rescuers, economic aid and international concern about contamination etc.). When the students reached a decision on the issue of whether they support nuclear power for Korea, they justified their position with information that they obtained from the media regarding the nuclear crisis in Japan. Interestingly, significant numbers of the students supported Korea's use of nuclear power generation even though they were aware of the potential dangers of nuclear power and mentioned safety as being an important consideration (75%).Their underlying reasoning seemed to be affected by the media information they were exposed to, but not in an expected way. For instance, they tended to think the only causes of nuclear power plant accidents are

earthquakes or tsunami. Thus, they made an argument in favor of Korean nuclear power because Korea is geographically safer than Japan. Students seem to easily take fragments of information from the mass-media to fit their claim. It implies that science teachers need to help students to deal with media information critically, because the media is an influential source affecting students' decision-making on socioscientific issues.

40. P1-B16

EVALUATION OF THE EFFECT OF COMPETENCE INDICATORS ON ENERGY CONSERVATION AND CARBON REDUCTION CAMP

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The goal of this study is to investigate the immediate influence and lasting change of students' knowledge, attitudes, and behaviors towards energy conservation and carbon reduction through the activity of energy conservation and carbon reduction camp. The participants are 85 junior and senior high school students in northern Taiwan, who joined the two-day program and were led by the teachers with relevant background knowledge. The program is combined with competence indicators of mitigation strategy across competence indicators of energy and climate change developed in this study, and its features are as follows. 1. Food materials are used from the local area, and vegetables are the main food materials as three meals (to decrease Food Mile). 2. Recycling tools are what is used in the activity and the game. 3. The meaning of Earth Day is understood through discussion and share, which spotlights the significance of energy conservation and carbon reduction. 4. The low-carbon trip is made to observe natural resources and consumption of the environment. The evaluation tool of this study is quantification of the questionnaire of energy conservation and carbon reduction (the Questionnaire of Knowledge of Environmental Education, the Questionnaire of Attitude towards the Environment, and the Questionnaire of Behavior towards the Environment). The pre-test was conducted before the activity, and when the activity finished, the post-test was used. After two weeks of the end of the activity, the delayed post- test was given to follow the post-test. The statistical data obtained from the above results are shown, and the Camp Feedback Form is analyzed to find out the students' preference, value, feedback, and suggestions for the activity as auxiliary materials. Finally, the effect of the study on the camp can be displayed. From the results, there is a significant increase in the scores of the Questionnaire of Attitude and Behavior towards Environmental Protection. The delayed post- test conducted after two weeks of the end of the activity shows that a significant increase in the scores of the Questionnaire of Attitude and Behavior towards the Environment compared to the pre-test, but there is no significant difference compared to the post-test. The results of the study indicate that the activity combined with competence indicators is helpful to promote students' lasting changes in affective development, behaviors of energy conservation and carbon reduction. Some suggestions on education, student guidance and research were also discussed.

41. P1-B17

SCIENTIFIC LITERACY REFLECTED WITHIN DECISION MAKING: BASED ON WRITTEN DECISION MAKING ABOUT SOCIO-SCIENTIFIC ISSUES

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Science without literacy is a ship without a sail(Jonathan Osborne, 2002). "Scientific literacy" become ubiquitous and represents what we expect students to know and be able to do as a result of their science learning experiences(Troy D. Sadler, Dana L. Zeidler, 2009). Scientific literacy highlights learners' use of science in real-life contexts(Troy D. Sadler, Dana L. Zeidler, 2009). Socio-scientific issues have become important in science education because they occupy a central role in the promotion of scientific literacy (Bingle & Gaskell, 1994; Driver, Leach, Millar, &Scott, 1996; Zeidler & Keefer, 2003). This perspective on scientific literacy requires students' ability to make informed decisions regarding scientific issues of particular social import(Troy D. Sadler, Dana L. Zeidler, 2005). It is necessary to explore how students negotiate and resolve socio-scientific issues(Troy D. Sadler, Dana L. Zeidler, 2005) and how students interpret evidence, and make their decisions response to socio-scientific issues. As growing importance of argumentation in science education, language becomes more important elements in science education. Argumentation make learners engage in the coordination of conceptual and epistemic goal and make students' scientific thinking and reasoning visible to enable formative assessment by teachers(Erduran, Osborne and Simon, 2005). So, we can trace students' thinking process and making decision through their spoken and written language. In this article, we explore students' scientific literacy reflected within written decision making about socio-scientific issues. In order to analysis, scientific literacy categorized into scientific knowledge, scientific method and argument and communication.

42. P1-B18

MERAPI MOUNTAIN ERUPTION AND ITS POTENCY FOR SOCIOSCIENTIFIC ISSUES EDUCATION

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Socioscientific issues (SSI) education may promote cultural-based value education in Indonesia. Unfortunately, it has not been developed yet in this country. The development of SSI requires some contextual problems which can be found in the society. Merapi mountain eruption which was happened at the last of October 2010 in Yogyakarta, Indonesia, remains some problems which are fully potential to be used for developing socioscientific issues education. This article discusses the problems which are occurred from the eruption phenomenon and how its potency for developing SSI toward value education in Indonesia.

43. P1-B19

A CONSIDERATION OF THE SCIENCE CLASS WITH THE THEME OF COLOR OF NATURAL THINGS AS TRADITIONAL CULTURE IN JAPAN

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In the recent educational practices in Japan, it is requested that the enhancement of traditional culture and the language activity are to be valued. Additionally, it is emphasized to develop a realistic understanding of natural phenomena, and to foster scientific perspectives and ideas in the elementary science class. This is the report of the teaching practices reflecting such trends in which the color of natural things were the subject as the traditional culture in Japan. 39 students (the 5 grade) had the science classes with the theme of "color" for 10 hours at an elementary school attached to the national University on September in 2010. At first, the students collected "green" things around them and were able to line up from pale green to dark green. Secondly, they learned that the name of plant, animal, and person was used as a part of the name of the traditional color (For example: TOKI-IRO, Toki is a name of a bird.) . The third, they named the pictures by themselves. The named pictures were 74 in total and 26 out of them were pictures of plant, 39 were pictures of sky (evening glow and rainbow were included.), and 8 articles were scenery of woods, rice field, desert. 27 articles (36.5%) were named using natural things like the traditional color. As a final activity, they tried the experiment of evening glow and rainbow. In the result of the questionnaire survey after that class, we recognized there was the strong correlation between learning the name of the traditional color and learning the origin of that color ($r = .86, p<.01$). In addition, there was correlation of medium degree between gathering the colored things and the experiment of light ($r = .48, p<.01$). And we knew the weak correlation appeared between gathering the colored things and learning the name of the traditional color as well as learning the origin of that color. We conclude that the students are able to learn the Japanese scientific perspective as well as science phenomena by some activities about "color" in relation to gathering the colored things of nature.

44. P1-B20

CHALLENGE TO SPECIAL EDUCATION PROGRAM FOR GIFTED AND TALENTED CHILDREN IN SCIENCE EDUCATION IN JAPAN -THE EXPLORATORY STUDY

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Science education in Japan has reached turning point. Japanese society realizes that it is important to make advances in science and technology to develop own country because of recent advances in technology in other countries. As a result, Japan pushes ahead special education for children who exhibit their talent in especially scientific field in addition to teach science knowledge and skills in certain level for all children. This is major change in Japanese public education which teaches all children equally in principle. First of all, this change appeared in "Super Science High School Program" in Japan. The high school which is assigned to the program is allowed to organize special curriculum to foster scientific ability. Financial support is also provided by Japanese government to accomplish their aim. This SSH program is appreciated, and the expansion is continuing. Secondly, "Fostering next generation science project" has been introduced now. This nationwide project is executed by university, and it provides youngsters who have outstanding talent and willingness in mathematics and science with opportunities of advanced studies. Appropriate full-year educational environment is provided in universities and technical colleges for advanced studies. Students will make presentation of their outcome in a public meeting. The difference between these two programs and project is that former is difficult to deal with individual characteristic because it is executed in the framework of high school education, but latter focus on individual talent to foster it. In the latter case, it is very important how to find talented individuals and how to foster them. Authors has involved in this project, and attempt to develop gift and talent of students. Recent researches suggest that good academic performance correlates with high emotional intelligence or high motivation. This report explores the individual characteristic of talented children who has been participated the project. The potential utility of the individual characteristic including emotional intelligence in the context of special education program for gifted and talented children in science education is discussed.

- Invited Speech 5
- Date: Thursday, October 27, 2011
- Time: 09:00 ~ 10:00
- Room: #2 (1F)
- Chair: Tom Thomson
  (Oregon Department of Education, USA)

'DOING' SCIENCE VERSUS 'BEING' A SCIENTIST:
Examining 10/11-Year-Old Schoolchildren's Constructions of Science Through the Lens Of Identity

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Abstract

The concern about students' engagement with school science and the numbers pursuing the further study of science is an international phenomenon and a matter of considerable concern amongst policy makers. Research has demonstrated that the majority of young children have positive attitudes to science at age 10 but that this interest then declines sharply and by age 14, their attitude and interest in the study of science has been largely formed. This paper reports on data collected as part of a funded 5 year longitudinal study that seeks to determine how students' interest in science and scientific careers evolves. As an initial part of the study, 6 discussion groups were undertaken with school children, age 10-11, to explore their attitudes towards science and interest in science, the findings of which are presented here. The children's responses are analysed through the lens of identity, drawing on a theoretical framework which views identity as an embodied and a performed construction that is both produced by individuals and shaped by their specific structural locations. This work offers new insights into the manner in which students construct representations of science and scientists.

Introduction

The issue of students' engagement with science has been a topic of enduring interest in the science education community for the past 3 decades. Major reviews have been conducted by Ormerod and Duckworth (1975) Gardner (1975), Schibeci (1984) and Osborne *et al.* (2003). Very little work has been conducted on what views young students hold about science – particularly not from a qualitative perspective that understands learning as tied to processes of identity construction (Holmes, 2000). This work offers, therefore, new perspectives on an enduring issue for the field.

A considerable body of evidence now exists that, compared to other school subjects, science is failing to engage young people (Jenkins & Nelson, 2005; Lyons 2006; Osborne & Collins, 2001; Sjøbeg & Schreiner 2005). Yet, student interest in science at age 10 has been shown to be high and with little gender difference (Murphy & Beggs, 2005). However, in the UK, research has shown that the point of decline begins in the final year of elementary school (Murphy & Beggs, 2005). Indeed, Ormerod and Duckworth (1975) devote a whole chapter of their review on attitudes to science to the considerable body of work which shows that interest in science is a product of student experiences by age 11, drawing on work conducted as early as 1874. A recent and particularly significant contribution to confirming this finding has been Tai *et al.*'s (2006) longitudinal analysis of NAEP data between 1988 and 2000 . Further recent evidence that children's life-world experiences prior to 14 are the major determinant of any decision to pursue the study of science comes from a survey by the Royal Society (2006) of 1141 science, engineering and technology (SET) practitioners' reasons for pursuing scientific careers. It found that just over a quarter of respondents (28%) first started thinking about a career in science, technology, engineering and mathematics (STEM) before the age of 11 and a further third (35%) between the ages of 12-14. Likewise, a small-scale longitudinal study that followed 70 Swedish students from Grade 7 (age 12) to grade 11 (age 16) (Lindahl, 2007) found that their career aspirations and interest in science were largely formed by age 13. Lindahl concluded that engaging older children in science would become progressively harder.

Our approach to exploring students' engagement with science is grounded in notions of identity – an understanding that sees the lack of interest in school science as a product of the mismatch between popular representations of science, the manner in which it is taught, and the aspirations, ideals and developing identities of young adolescents. Indeed there is a large body of work that would indicate that students' sense of self-identity is a major factor in how they respond to school subjects (Head, 1985; Schreiner & Sjøberg, 2007). Our theoretical approach understands identity as both an embodied and a performed construction (Butler, 1990), that is both produced agentically by individuals *and* shaped by their specific structural locations (e.g. see Author1, a; Author1, b). Identities are understood, therefore, as discursively and contextually produced (i.e. produced through practices, relationships and interactions within specific sites and spaces) – and as profoundly relational. That is, a sense of self is constructed as much through a sense of what/who one *is not*, as much as through the sense of who/what one *is* (Said, 1978). Importantly, notions of identity are multifaceted and complex, being shaped in relation to intersecting axes such as gender, ethnicity and social class, which can generate powerful notions of what is/not appropriate or normal for 'people like me' – which in turn can profoundly shape individuals' educational choices and trajectories (Bourdieu & Passeron, 1977).

This paper seeks to explore then how such research-informed approaches can help to understand and address key challenges in enhancing participation, engagement and achievement in science and mathematics, in particular to address differences linked to socio-economic status, gender and ethnicity. In particular, the paper represents an attempt, at the start of our project, to set out potentially useful concepts for working with, and to map key avenues for exploration over the next five years.

Study Design and Sample

The data for this paper comes from an ongoing five-year longitudinal study (funded by the UK ESRC Special Initiative on Science and Mathematics Education) that aims to develop an understanding of the processes underlying the formation of young people's aspirations and their engagement with science. Data for the larger project will consist of a quantitative survey (to be administered to approximately 9000 students at age 10 and subsequently at ages 12 and 14) and qualitative, longitudinal tracking of 60 pupils and their parents over 4 years. In order to inform the design of the quantitative survey, 6 discussion groups were undertaken with 42 students drawn from a range of schools in the London area. The students differed markedly both in socio-economic status and ethnic diversity. The fundamental aim of this methodology is to gather data on the topic and participants' perceptions and understanding. Thus, in selecting our sample, we sought to recruit a selection of students who varied widely by socio-economic status, gender and ethnicity. Such research seeks to develop a deeper understanding of its central focus exploring not only what participants think but why they think it (Kitzinger, 1994). As such, the goal is not necessarily to produce data that can be generalized to larger populations, but rather, to explore the range of attitudes, values and beliefs that are commonly held, the strength of feeling, and the reasons for those beliefs. Whilst previous research suggests that data saturation is achieved after three to four discussion groups, generalizing to a wider population must always be undertaken with caution (Vaughan *et al.*, 1996) particularly as we make no claim about the representative nature of our sample. Essentially, discussion groups seek to expose what Schutz and Luckman (1973) have termed the 'intersubjectivity' – the collective description of everyday reality and its variation. The data emerging from such work provides a valuable tool for representing the world as it is perceived by the group and their interpretation of experience.

For the purpose of the discussion groups, a set of questions was developed which formed a loose structure for exploring these young students' views. Students were assured of the confidentiality of the data and each group lasted for approximately an hour. The discussion groups were conducted by the second author (a white American woman) and were digitally audio-recorded and transcribed. Then, using a Foucauldian analysis of discourse (Burman and Parker, 1992), data were searched iteratively to identify the major themes, constructions and discourses articulated by these young students.

Pseudonyms have been assigned to the participating schools: 'Inner City Elementary' (1x girls group, 1x boys group) is a small urban elementary school situated in area of high social deprivation with a large immigrant population (particularly from Bangladesh, Pakistan and Africa). Most of the students attending the school are eligible for free school meals and many do not speak English as their first language. 'Private Elementary' (1x group boys, 1x group girls) is a large selective, fee-paying school (admitting children from age 3-16). It is located in an affluent area of the city and the majority of the children attending the school are from White British backgrounds. 'Roman Catholic Elementary' (1x mixed sex group) is a large, popular school located in an inner city area of considerable deprivation. The main pupil groups are those from White British and Black African backgrounds and the majority of those attending are baptised Catholics. It is a publicly funded faith school (receiving additional support from the Catholic church). 'Urban Elementary' (1x mixed sex group with members of the science club) is a large inner-city school in which almost all students come from minority ethnic backgrounds (the largest group being those of South Asian descent) and a very high proportion speak English as an additional language. An above average proportion of students are eligible for free school meals.

'Doing' versus 'Being'

Our analysis of the role of identity within children's constructions of science is broken down into two major themes, namely 'doing science' and 'being a scientist'. These were not specific questions within the interview protocol but were identified within the analysis of the data as two broad, common structuring discursive distinctions within the children's talk. As will be argued below, the importance of this conceptual distinction underlies many of these young students' ability to both reportedly enjoy science (most did) but not want to continue with science in their future careers – to 'become' a scientist (most did not). Our analyses thus highlight a key dilemma, namely that children can report enjoying science (e.g. they may find it fun, exciting, important and interesting) but they may still choose not to study it at higher level. As we shall argue, these two areas were comprehensively infused with issues of identity and were circumscribed by social class, ethnicity and gender, such that some options, even at this age, are beginning to be ruled out as not only undesirable but even 'unthinkable', whereas other possibilities are understood as desirable only under certain conditions.

'Doing Science': Safety versus danger

Under our major theme of 'Doing Science', our data largely echoed what is known from the existing literature, namely that student interest in science at age 10 tends to be relatively high with little gender difference (Murphy & Beggs, 2005; Pell & Jarvis, 2001). Most of the children who took part in the discussion groups reported enjoying science at school. This enjoyment was predominantly framed in terms of the practical mastery of 'doing' science, namely the 'hands on' elements of practicals and experiments, a preference that has also been noted in other work (e.g. Solomon 1980; Osborne & Collins 2001). We found across the discussion groups that the children's attachment to this form of 'doing' science was framed within a discourse that we have termed 'danger vs. safety', in which 'real' science is constructed as 'dangerous' (and exciting) and is placed in tension with school science (particularly elementary school science) due to the latter's concern with 'safety'.

Boys and girls both associated science with explosions and bangs, as one girl put it, 'pouring liquids to make, like, an explosion'.

> *Int:* *… So if you had to explain what science is to somebody who'd never heard of it how would you explain it?*
> *Boy:* *Bangs.*
> *Int:* *Bangs?*
> *Boy:* *Just to say it could hurt your ears.*
> *Boy:* *It's interesting and you won't know what's going to happen next.*
>
> *(Inner City Elementary, boys)*

While both boys and girls were likely to find this flamboyant and explosive nature of science interesting and engaging, there were suggestions of orientations that were differently gendered to this evocation of danger. For instance, one girl's rationale for not wanting to continue with science in the future was: 'I don't want to get my head blown off by chemicals' (Inner City Elementary, girl). Indeed, girls were considerably less likely than boys to cite their interest in science as due to 'explosions' (Jenkins & Nelson 2005).

It was also notable that considerably more boys than girls spent time discussing the 'dangerous' nature of science, which was juxtaposed with the restraints they felt were imposed by their schools in terms of 'safety'. As one boy at Inner City Elementary explained, 'science is the dangerous kind of experiments and in school we don't do that stuff'.

> *Boy 1:* *It's like a lot of* ***real*** *stuff, like the real scientists they do like chemical work - we just do like (inaudible)*
> *Int:* *Mm, okay.*
> *Boy 2:* *We do like the boring safe things, but they do*

experiments which are dangerous

(Urban Elementary, Science Club, mixed group)

Girl: They [Scientists] do more dangerous stuff than we do in school.

Boy: That's what I was going to say, I was going to say that in school we kind of [⋯] We can't really go past the boundaries because it's too dangerous. Sometimes it gets frustrating because you know that nothing's really going to happen to you. But the school, obviously they want you to be safe and it kind of is annoying.

(Roman Catholic Elementary, mixed group)

The boys at the private Elementary agreed, bemoaning that they are not allowed to do 'really big experiments⋯ like using acids and stuff' because 'it's a lot safer at school'.

It is interesting to note in these extracts how 'real' science is already being constructed in gendered terms. Whilst, amongst the sample of ten year old children, both boys and girls reported enjoying doing science, we can see here how they are starting to articulate a dominant discourse in which 'grown up' science is constructed in masculine terms: as 'dangerous', risky and potentially unpredictable (and hence, by implication, exciting and innovative). Whilst the children do not consciously use the language of gender themselves, these attributes are clearly gendered and are aligned with masculinity (Francis 2000; Skelton & Francis 2008). The distinction between 'grown up' science and school science (which becomes positioned through a binary opposition as 'immature', 'not real science', as 'safe' and as feminised) also suggests that those boys and girls who are attracted to this discourse of science perceive that there is an identity gap that will be have to be endured or negotiated if they are to continue with science. That is, the children identify a disjuncture between an attractive, desired vision of 'real' science and a less attractive version of school science that must be pursued in order to become a scientist in the future. The overlaying of gender onto this disjuncture creates an additional identity conundrum – namely that an engagement with a 'feminised' form of science is the necessary path to achieving (a more desirable, higher status) masculinised identification[i]. One boy at a private Elementary also provided some indication of the identity work that he undertook to try to navigate this disjuncture, adding the justification that 'well, if you think about it all good scientists have to start off at this stage'. It seems, therefore, that while these young children may not have comprehensive or detailed knowledge of what a future career in science might entail, they are tacitly learning from an early age that it is associated with masculinity.

As illustrated above, many boys positioned their elementary schools as spaces in which science is infantilised and 'made safe' (see Skelton 2001 on the dominant feminisation of elementary schools). The 'safe' elementary school was juxtaposed against the fantasy of secondary[ii] schools as placed where more desirable and 'real' ('dangerous') science might take place. A number of children, especially boys, talked about their keen anticipation of secondary school as allowing them to (literally) 'play with fire, like Bunsen burners' (Inner City Primary, boys), 'when we get to secondary school we might be able to use fire' (Roman Catholic Elementary, mixed group, see also Urban Elementary, Science Club, mixed) – an expectation often fulfilled and well captured by Delamont *et al*.'s (1988) eponymous article 'In the beginning was the Bunsen Burner'. The frisson of danger associated with secondary school science generated a sense of excitement and anticipation ('in secondary school it's more dangerous', 'it's better because they trust you with more dangerous chemicals, stuff like that'; 'dangerous stuff like explosions, mixing acids together, seeing what different chemicals do to each other').

It appears from these initial data that the boys have constructed a close (anticipated) alignment between popular masculine identities and secondary school science. While in some ways this is encouraging (because these students are imagining that they will become yet further engaged with science at secondary school), it also introduces the risk that they will be disappointed if the science they are presented with at secondary school fails to live up to their fantasy of danger. Indeed, evidence suggests that while secondary school science may initially contain some of these exciting elements, it quickly

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[i] The conceptualisation of gender that we use does not treat gender as tied to particular sexed bodies, i.e. girls can identify with, desire and engage in performances of masculinity and vice versa with boys and femininity. Although dominant social power structures mean that boys tend to perform masculinity more consistently than girls and that these performances tend to be judged as more 'authentic' (and vice versa with girls and femininity).

[ii] Secondary schools in the UK take children from ages 11-16 or 11-18. There are comparatively fewer middle schools.

becomes more theoretical, demanding more writing than practical work (Osborne & Collins 2001). Given the dominant popular equation of writing with 'feminised' forms of learning (Skelton & Francis 2008), it might be reasonable to assume that these boys' disillusionment with the demise of the practical/spectacular nature of science will be even more pronounced.

One possible policy response might be to suggest that secondary school science be reformed in ways that would emphasise and play up its 'dangerous' potential. This echoes wider educational policy initiatives in the UK, US and Australia that have arisen from the debate about boys' underachievement, in which attempts have been made to increase boys' engagement and attainment in particular areas (especially those that are 'feminised', such as English/ literacy) by making them more 'masculine', and hence attractive to boys (e.g. schemes that use football to increase the appeal of literacy). Such approaches have attracted considerable feminist critique for playing into gender binaries, for reinforcing dominant (hegemonic) forms of masculinity and for having negative implications for not only girls but also 'other' boys (not all boys identify with dominant forms of masculinity). Moreover, as we discuss further below, the conceptual binary that we have identified within the children's talk between 'doing science' and 'being a scientist' would suggest that enjoyment of (and indeed, competency in) school science does not straightforwardly translate into the sense that one wants to (or could) 'be' a scientist. In other words, increasing a pupil's enjoyment of 'doing' science will not necessarily translate into their uptake of a science identity.

Doing Science Outside School: 'being naughty' or 'being good'?

As we have so far discussed, most of the school children we interviewed felt that the science they practised in school bore little or no relation to the science practised in the 'real' (grown up) world. Indeed, criticisms of the gap between school science and 'real' science are not new – and calls continue to be made to increase the 'real world' relevance of science in order to better engage young people (e.g. Calabrese Barton, Ermer, Burkett, & Osborne, 2003).

In the discussion groups, we asked the children if they ever practised science outside of school and found that many talked about performing their own 'experiments' at home. This might be seen as a heartening endorsement that not only are these children interested in science in school but they are incorporating this interest into their leisure time. However, we also identified some distinctly classed and gendered patterns within these accounts of 'doing science at home' which might help explain some of the different, distinctive patterns of engagement with science that emerge in older samples of students. That is, the different ways in which these ten year old children engage with science in their leisure time may be indicative of some of the processes that feed into their differential likelihood to attain well and continue with science in the future. We have identified a distinction between those students who described their out-of-school science activities as informal and as part of having fun and being mischievous (*being 'naughty'*) and those students who practised science in a more formalised way, relating to recognised school science curricula and whose activities we would interpret as feeding into the larger project of working on developing/enhancing their 'good pupil' identities (*being 'good'*). The following extracts exemplify the responses of those who talked about doing science out of school as something fun and 'naughty' – the children are talking about what they like to do in their leisure time and if they ever do any science at home:

Boy: I like at home going out and getting Coke, and then getting salt, going to my enemy's house, and then I put salt in the bottle, then like shake it up and it will fizz up, and then I will knock on the door, they'll open it, I open it - and that's it!

(Inner City Elementary, boys)

Boy 1: I fill up a balloon and like blow it up on people.
Int: How is that science?
Boy 2: Because we can see how the H_2O blows up and⋯
Int: Oh so it's a water balloon?
Boy 1: ⋯and causes an explosion and all that.
Boy 3: H_2O is water.
Girl 1: I've got this set and it's called (inaudible) and you do experiments with it.
Int: Okay, uhuh.
Girl 1: And like you like stick all the different (inaudible) the little powder bits in like a balloon and then it all blows out (inaudible)

Int: Oh cool yeah.
Girl 2: I use my 'Grow my own Crystals' kit.
Int: You use your what?
Girl 2: Grow your own crystals.
Int: Oh yeah, yeah. What about you?
Boy 4: Um, sometimes I get some balloons when I'm bored, and like rub it on my jumper or rub it somewhere, and stick it on my head.
(Roman Catholic Elementary, mixed)

There were numerous accounts across the groups (mostly, though not exclusively, voiced by boys) where students talked excitedly about practising science in terms of creating 'explosions'. As one boy from Inner City Elementary put it, 'Science can be really fun, if you're being naughty'. Indeed, putting Mentos (chewable mint sweets) into Coca Cola to make it fizz and explode was mentioned as a popular pastime among many of the boys we talked to (and indeed one of the girls at Roman Catholic Elementary). These activities clearly engaged the children and form part of the spectacular and 'risky' vision of science that they were attracted to, as discussed earlier. As also illustrated in the above extract, the two girls mentioned more formalised engagements (e.g. the crystal set) than boys. The gendered aspect of this 'naughty' engagement with science can be read as part of the young boys' performances of 'laddish' masculinity, a contemporary form of popular masculinity. 'Laddish' masculinities are the subject of considerable interest and interrogation within the gender and education literature and have been identified as an international phenomenon (Jackson, 2002; Francis 1999). Whilst laddishness is usually discussed with reference to older samples of boys and young men, it has also been noted as an important identity practice/discourse within elementary pupils (Renold 2005; Skelton 2001) – albeit in a more immature form than its adult manifestation. 'Laddishness' derives from the notion of the 'lad' – a young man who performs a gender-traditional (or monoglossic, Francis 2000) masculinity, who engages in hedonistic practices (such as drinking, womanising), is confident, 'cheeky', 'cocky', mischievous and entertaining (enjoys 'having a laugh', 'back chatting' teachers). The identity of the lad is oppositional to that of the studious 'geek' or 'nerd' – the lad is not studious or conscientious, he engages in public displays of 'not working' and keeps any effort or school work strictly 'under cover' (Frosh *et al*., 2001). As the literature suggests, laddish identities are not homogeneous (boys may perform some aspects but not others; laddish identities are not constant or consistent) nor are they solely restricted to boys (see Jackson & Tinkler 2007 on the rise of the 'ladette'). However, in the UK they do constitute a popular and pervasive discursive reference point and resource within many boys' (and girls') identity constructions.

Whilst the children cited above do not embody the excesses of laddish identity, their youthful exuberance for the 'naughty' and fun side of their informal engagement with science does point to the allure of such identities. Their talk suggests again (as in the previous section), that for some boys, the most popular, fun and accessible aspects of science are those aligned with hegemonic masculinity. Moreover, the nascent laddishness hinted at within the children's accounts (albeit framed here as being mischievous) would suggest that this popular engagement with science through hegemonic masculinity will not necessarily translate into later formal academic engagement with science. This is because laddish performances of masculinity tend to be predicated on a distaste for school work which becomes more trenchant with age. Thus, our point is that, while these children's accounts of a joyful engagement in out-of-school science can indeed be valued in their own right, this form of engagement may not necessarily extend to a continued formal educational engagement with science.

In contrast, some children (but particularly- though not exclusively- those from more 'middle class' backgrounds) talked about more formalised engagements with science outside of school – a discourse that we have characterised as 'being good'. These children described reading reference books, owning microscopes and playing with science sets (such as the experiment set and the 'grow your own crystals' set mentioned by the girls in the preceding discussion extract and the magnet set commented on below). One boy (at Inner City Elementary) described helping his uncle who worked in a laboratory. These children also talked about trying to replicate experiments conducted at school when at home. For instance, a boy at Inner City Elementary talked about how he had dissected a flower at home and a boy at Roman Catholic Elementary explained 'when we were in Year 5 someone mentioned salt water and see how long it would dissolve or something, so I went home and tried it'. The joy of learning about and practising science was clearly something they took pleasure doing in their time at home:

Boy: Well I look up books for experiments and sometimes look stuff up about the ozone layer etc. So it's much more different from school than I learn at home. But it's also quite fun.
(Private Elementary, boys)

Boy 1: I've got a magnet set at home.
Int: Mm, okay yeah?
Boy :2 I've got a magnifying tele- … it's a microscope that you connect to the computer, and you can see everything like snowdrops.
(Urban Elementary, Science club, mixed group)

Whilst these children also describe their out-of-school science activities as fun, there is a discernibly different feel to the form of their engagement, as compared to the 'naughty' explosions outlined above. These children's engagement with science at home reflects a greater use of 'cold' (formal, official) knowledge (Ball & Vincent 1998), such as reference books and educational sets. This access to and comfort with cold knowledge has been found to be more common among the middle classes (Ball & Vincent 1998). These activities, such as consulting reference books, replicating experiments taught at school, working with adults, using microscopes and educational sets and so on, are more structured and closer in content and form to the formal learning that takes place within schools. As such, we would hypothesise that such practices are more likely to translate into cultural and educational capital (Bourdieu, 1986, 1990). That is they contain a clearer potential to facilitate the children's attainment and progress in school science and to nurture and feed into the children's self-identifications (and indeed their teachers' assessments of them) as 'good students'. Indeed, we might even read these instinctive engagements with out-of-school science in light of sociological theorisations of classed parenting and childcare practices which have been linked to the production of classed patterns of educational advantage and disadvantage. Working-class family practices tend to be associated with the 'accomplishment of natural growth' (Lareau 2007), in which children's development is not the subject of excessive intervention (to which we might map on those children's instinctive and unstructured engagements, epitomised by the 'Mentos in Coke' explosions, which tended to be conducted by children playing among themselves, rather than under adult supervision or tutelage). In contrast, middle-class families have been associated with more interventionist and structured approaches, a 'concerted cultivation' (Lareau 2007) of their children, often through an orchestrated programme of educational 'enrichment' activities (Vincent & Ball 2007) which aim to develop a range of skills, interests and capabilities within the child – which in turn help foster 'success'. In this respect, we might read the 'being naughty'/ 'being good' distinction in informal science practices as another field in which distinctions are germinating with regard to later patterns of achievement and engagement with science (see also Gladwell 2008 regarding the significant advancements noted after the summer vacation period for middle-class US students compared to their working class peers)[iii].

As the following extract from the girls at Private Elementary illustrates, middle-class parents are more likely to utilise their cultural capital to generate opportunities for structured learning at home, such as buying books, science sets and resources and seeking additional information from schools to enable them to support their children to do 'proper' experiments at home.

Girl 1: And when my parents went to parents evening they managed to get a website where you can like make sherbet and make (inaudible) and dissolve things, and it's really interesting doing that.
Girl 2: Well I think it's good cos we can, because we like made lava lamps … well ones that only work once. It was really funny cos they're quite easy to make. But she just showed us how to make it and how it worked with olive oil and stuff.
Fac: Oh wow.
Girl 2: And then it's really easy to make at home.
(Private Elementary, girls)

One of the girls also talked about how 'I experiment with lots of little things at home'. She described a science book she owned that she was working through at home (because 'I can do science but I can't do it perfectly') which enabled her to 'make experiments at home, like how to make putty'.

It was notable that it was only in the private (fee-paying) school that pupils mentioned explicit parental in-

[iii] The other distinctions at work within the students' constructions of their out-of-school science activities is the focus of forthcoming work, in which we explore the higher propensity for South Asian students in our questionnaire sample to undertake science activities at home.

volvement in this way. This may indicate one of the many potential 'small acts' and everyday practices that, over time and in sum, can help to foster higher levels of achievement and engagement with science among particular social groups.

Indeed, the potential importance of out-of-school interests and activities has been flagged elsewhere (Kelly, 1981; Ormerod & Duckworth, 1975; Woolnough, 1994). Mendick *et al*. 2009 conducted a survey with 560 year 10 pupils from three comprehensives and 100 2nd year mathematics undergraduates in 2 universities and found that 40 year 10 students rating themselves as 'very good' at maths displayed a different and distinctive relationship to maths within popular culture. That is they were 'much more likely to play tetris and chess and to do sudokus and cryptic crosswords than other students' and were 'most likely to carry on with maths' when it became optional at age 16. Indeed, it was notable that among our sample that the few children who embraced a potential future identity as a scientist linked this identity to their interests and activities at home (as opposed for instance to their interests or achievement at school):

Boy 1: I want to be um an inventor or …
Boy 2: Scientist.
Boy 1: … yeah scientist … or possibly an archaeologist.
Int: Ah, and why do you think you might want to be those things?
Boy 1: Because mostly at home I make inventions and stuff.
(Private Elementary, boys)

'Being a Scientist': The Scientist as Other

We have so far explained that whilst the majority of ten year olds we talked with enjoyed 'doing' science, the seeds of later distinctions and patterns of attainment and uptake of science are already becoming evident. In this section we explore the limits of this boundary of 'doing science' and the problematics of its translation into 'being a scientist' (ie. the taking up of a science identity). We will suggest that the main issue at stake here is the potential to construct and inhabit an intelligible science identity – one that is valued in and for itself, that is congruent with other aspects of a person's identity and that is also (seen to be) judged by others as being of worth.

Underlying our understanding of the reasons why an enjoyment of 'doing' science may not translate into wanting to 'be' a scientist is the argument that this disjuncture is particularly likely to occur where science, as an identity discourse, is experienced as clashing with popular hegemonic forms of masculinity and femininity. Given that the latter are often intensely held identities, evoking strong emotional attachments and experienced as profoundly personal identity constructions, it is unsurprising that they effectively 'trump' the viability of a science identity. For instance, a boy in Roman Catholic elementary school agreed that he found science 'fun' but could not countenance becoming a scientist because, for him, it is 'football and wrestling always' – an expression of the evident allure of hegemonic masculinity. Indeed, football and wrestling do not even have to achieve the status of being distinctive career goals – their mere possibility is sufficient: 'I don't want to be a wrestler – its just something that I like, that I might want to be a wrestler. I might not.' Girls also voiced highly gendered discourses in which they resisted the idea of becoming a scientist because 'I don't want to touch too many dead things' and 'I wouldn't like to see people like, their things and everything .. yeah and I'm not really into these science like skulls and ears and stuff' (Inner City Elementary girls). Whilst a substantive literature already exists pertaining to the gendered construction of children's aspirations and subject choices (Francis, 2000; Kelly, 1981; Lightbody & Durndell, 1996; Whitehead, 1996), we suggest that to understand the doing/being disjuncture further it is useful to look in more depth at the content of the children's constructions of scientific identities and the ways in which these are not only gendered, but are also inflected by social class and 'race'/ethnicity.

Science as 'Hard'/ ' Brainy'

Science was overwhelmingly constructed as a 'hard' (difficult) subject that required and demands application. However, the hard or difficult nature of science was something that many of the students reported as attractive. For instance, the boys at Inner City elementary complained of their frustration with a teacher's attempt to make science 'simple', arguing that this rendered science less interesting.

Bo*y 1: She [teacher] knows a lot but it's boring.*
Fac: Ah, the way she's teaching it?
Boy 2: She doesn't put emotions in it.

> *Boy 3: She tries to make it simple but she makes it so simple that she tells us all the stuff you already know.*
> *Boy 2: Exactly.*
> *Boy 1: It's not interesting.*
> *Boy 3: We like it when it's so complicated we try to think it out with our brains, but she's always like 'I'm making it simple. If I do any simpler it would be cheating' and I'm like 'We don't want to cheat, so make it harder.' We want to test our brains.*

As the last comment, above, illustrates, these boys enjoyed the challenge of science as a 'complicated' subject that requires students to use their 'brains'. Indeed, the terms 'brain' and 'brainy' were highly prevalent across all the children's transcripts (e.g. 'it gets your brain going', Inner city Elementary boy), which we would interpret as reflecting the status associated with subjects such as science, that are closely aligned with notions of intellectual rigor. This link (between the 'braininess' of a subject and its social status) was made explicitly by the girls in the Private Elementary, who answered the question of what makes science fun saying 'when we learn like the really brainy things, like the things you don't learn if you're in a state school'. These constructions are gendered and classed (being read as middle-class and as masculine, see Harding 1986) and hence are more likely to 'fit' with middle-class students' everyday notions of desirable masculinity and femininity, being especially appealing for middle-class boys. As one boy at the independent Elementary school explained, what he liked about science was 'when you learn stuff that you can like sound cool with'.

Children imagined that the science they would encounter in secondary school would be even harder and that this would be 'a good thing' because it would require them to 'use our brains more'.

> *Boy 1: But we've got to use our brains more. There are going to be a lot more harder questions and harder experiments to do*
> *Fac: Uh huh. Do you think that's a good thing? A bad thing? Neither one?*
> *Boy 1: I think it's a good thing*
> *(Roman Catholic Elementary, mixed group)*

Although the notion of science as 'testing your brain' was seen as attractive, one boy suggested that it can make your brain 'kind of tired' with the risk that 'you just get confused'.

The discourse of 'science as hard' has been noted within other studies as a prevalent popular discourse, reproduced by students and teachers alike (see Carlone 2004). However, whilst studies, such as Carlone's, with older students have drawn out how this discourse of 'science as hard' collapses into a discourse of 'scientist as naturally clever/intelligent', this link was not immediately evident within these children's accounts. Whilst 'being a scientist' was in some instances linked with being intelligent ('I think their [scientists'] intelligence makes them good at their job'), the 'brainy-ness' of science was configured in a complex relationship with effort and ability. These younger students argued that one need not be naturally 'clever' to be good at science, even though it is a 'brainy' subject. Rather, they felt that interest, application, effort and 'concentration' were more important (for instance the Science Club children suggested ways of improving in science: 'Just depends if you like it or not and whether you concentrate'; 'Try and keep an open mind'; 'Don't learn about just like certain subjects and topics, learn about all different topics').

This sentiment (that one does not have to be 'clever' to be good at science) was echoed across the discussion groups. Whilst it is encouraging that these ten year olds had not reached the point of closing off science as the preserve of the 'clever', their discourse also contained contradictory elements, which point to how the dominant adult discourse (of science as for the 'clever', that has been found by numerous other studies) might come to be solidified among older students and adults. We suggest that this is encapsulated in their parallel discourse of science as 'natural interest', to which we now turn.

Science as 'Natural interest'/ Natural ability

When asked what makes someone good at science, students across the groups overwhelmingly drew on a discourse of 'natural interest' ('you have to be interested in all types of science'), arguing that the possession of this 'natural interest' (liking and enjoying science) provides the motivation to pay attention, remember facts and to do well in science classes. It also provides the impetus to engage in more, additional, learning about science.

> *Int: Do you have to be really clever to be good at science?*
> *Boy: Sometimes when you're like doing something,*

you can hear like interesting facts, or like really good stuff about science ··· you can remember it and then, cos you heard that, you could get interested in science. And then you would study ··· you would want to know more about science, so you look for more facts and more other stuff about science. And then you eventually ··· you become really good at science
(Inner City Elementary, boys)

Girl: The most important thing a science person must have is they like science – that's the most important thing. And if they like science, they have everything to do with science
Int: yeah?
Girl: They've just got to be able to enjoy themselves and not like say everything's hard, they've just got to try and enjoy it
(Inner City Elementary, girls)

This theme, of liking science and possessing a natural interest in it, at first appears meritocratic: as long as a student is interested and motivated, they can do well at science. However, there were also suggestions that the discourse might, over time, slip into an essentialised, embodied manifestation – that is the notion that there is a 'science person'– the individual who is naturally interested in science and who has a science 'mind'.

Fac: What would you tell them if they wanted to be good at science? How would they do that?
Boy 1: They should learn. They should study on the weekends or after school. Do extra lessons maybe or tell the teacher you don't understand and they will help you.
Girl: Yeah, try experiments, do experiments that they haven't done before.
Boy 1: And share it with the class.
Boy 2: I think that you shouldn't like be that eager to learn science to be very, very good, I think you should just do science like normally in life, and have fun with it and naturally you will graduate in your brain, your mind will go on ··· it will increase in science.
(Roman Catholic Elementary, mixed group)

The last remark in the above extract hints at this notion: one should not be too 'eager', rather science should be undertaken 'like normally··· have fun with it' and this will 'naturally' increase both competence and interest in science. The emphasis on 'naturalness' contains echoes of popular discourses in which science and maths are associated with particular sorts of person, the science person (Carlone 2004) or the maths person (Mendick 2006) who has a natural (innate?) ability and interest in science or maths and thus does not find it a chore or have to try too hard to learn about science or maths. The notion of there being a 'science person' was also reinforced by several discussion groups' references to other children in their schools or year groups who were known to be 'good at science' or interested in science. Several groups of students mentioned in passing (there was no direct question on the topic) these other children who were known as being 'science people'. For example, the children at Roman Catholic Elementary talked about a boy in their class who was known for wanting to become a scientist ('that guy loves science'). The Private school girls also described a known 'science person':

Int: And do you any of you all want to be scientists when you grow up?
Girl 1: I think that this boy in our class named [name], I think he wants to be a scientist.
Girl 2: He's really complicated.
Girl 1: Mr [name], he gave us a shortcut for this answer, and he [boy] goes for the most complex scientific proper maths ways, and so does his brother.

This was not unique – other groups also made reference to peers who were 'known' as interested in pursing science suggests that science is already operating here as a marked identity. This is irrespective of the claim that the children also made that anyone can do science if they want. Here the 'real', authentic science identity is distinctly embodied by particular individuals (notably 'complicated' and 'complex' individuals – see next section on 'the boffin'), suggesting that whilst anyone can 'do' science, only a few will really 'be' scientists, and that the identity of these children are popularly 'known' from an early age.

The discourse of 'natural interest' links closely with the idea of there being a 'science person' – someone who is naturally interested in science and who has a 'science mind'. Mendick *et al*'s (2009) research with children and young people highlighted popular constructions of a 'maths person' who has a 'maths mind'. Whilst at one level this construction might seem innocuous, it operates as a powerful embodied discourse that constructs a rigid division, akin to the distinction between 'science people' and 'non-science people'. Whilst the children in our study do not subscribe (yet?) to such distinctions, their instinctive use of a discourse of 'natural interest' might be interpreted as signalling how their current simultaneous construction (of 'anyone can do science if they try') may become eclipsed in later years by the discourses of 'science as natural interest' and 'the science person'.

Mendick *et al.* (2009) argue that the power of the construction of the 'maths person' is predicated upon its association with notions of 'natural ability'. This obviously sits in an uneasy relationship with a discourse of excellence as achieved through effort, although as Mendick *et al.* note, the two are often voiced together:

> There is a complex relationship between natural ability and hard work, with most people supporting both the idea that you can get better at maths through hard work and the idea that some people are naturally more able to do maths than others.

In other words, they argue that there is a recurrent contradiction between the notions of natural ability and improving through effort and 'a recurrent opposition between being a hard worker and being naturally able' (Mendick *et al.*, 2009).

The discourse of 'science as natural interest' also links in with dominant constructions of educational achievement as configured through natural ability (Walkerdine 1988, 1989, 1990; Skelton & Francis 2008). As a wealth of research has demonstrated, within dominant educational and popular discourse the identity of the 'ideal pupil' is popularly constructed as epitomized by 'effortless brilliance' (which is configured as male), which is located oppositionally to 'diligent' and 'plodding' achievement (which is configured as female). The prevalence of this binary has been noted internationally as characterising many teachers' talk. It has also been noted within science classrooms, for instance, boys in the Physics classroom studied by Carlone (2004) in the US and in the UK classrooms studied by Warrington & Younger (2000) were constructed by teachers as being more 'naturally' able in science. Girls were constructed as diligent and hard working, but lacking the flair and effortless brilliance of their male counterparts. The researchers noted that all these perceptions were irrespective of actual achievement (i.e. not all 'brilliant' boys were achieving highly and even the highest achieving girls were described as owing their attainment to 'hard work'). Against this powerful discursive backdrop it is perhaps not surprising that many girls and young women come to see their identities as inconsistent with dominant constructions of the 'real' or authentic scientist, whose identity is associated with 'raw' (Carlone 2004), 'natural' talent, interest and ability.

Indeed, Mendick (2005) details the considerable identity work undertaken by students in a Further Maths (an advanced level upper mathematics) class to avoid identifying as being 'good at maths'. She found that students tended to attribute their success in mathematics to their 'doing' (diligence, working hard) as opposed to being attributable to 'being' good at maths. This was particularly the case for girls. Mendick argues that being 'good at maths' is 'a position that few men and even fewer women can occupy comfortably … they persist in constructing the mathematician as something you are or are not 'naturally'' (p.216)

Scientist as Boffin

Closely related to the preceding themes of 'science as hard' and 'science as natural interest', we identified the construction of 'scientist as boffin'. 'Boffin' is a colloquial term used in the UK, Australia, New Zealand and South Africa, similar to the American notion of an 'egghead':

> Boffins are 'scientists, engineers, and other people who are stereotypically seen as engaged in technical or scientific research. The word 'boffin' (or 'boff' - often as an insult) can also be used to refer to any particularly clever person. The closest American equivalent is Egghead'
> (Wikipedia, http://en.wikipedia.org/wiki/Boffin).

In UK schools, the term 'boffin'/'boff' is used generically (it is not just restricted to science) to denote (and often ridicule) high achieving students who are associated with notions of 'cleverness' (Francis 2009). The science boffin is embodied by the popular and familiar stereotypical representation of the brilliant but eccentric scientist, epitomized by his 'wild' hair and distinctly marked in racial, age, gender and class terms as white, old, male and middle-class. In our research, Einstein was most often evoked to capture this representation.

Boy 1: 'When I hear science I usually think of this *man with a big moustache and like bald here [points to own head] and like with hair all around his head, and then*

Boy 2: Robert Einstein

Boy 1: Yeah, Robert Einstein. And he's got a flask in his hand and he has this green liquid and he pours it into another bottle another flask that has red liquid and then all of a sudden- caboom!

Boy 2: Chemicals

Girl 1: Like explosions like you know when you like [inaudible]

Int: You mix things up, yeah

Boy 3: He's wearing glasses

Girl 2: Like goggles

(Roman Catholic school- mixed)

Fac: What makes someone good at science?

Boy 1: When they know a lot.

Int: When they know a lot? What about you, what were you going to say?

Boy 2: I was going to say the same.

Int: When they know a lot?

Boy 3: When they have big moustaches and they're a scientist.

The notion of the scientist as a brilliant (if eccentric) genius has also been noted in popular stereotypes of mathematicians (Epstein *et al.*, in press), who observed how often, within young people's views, there is a conflation between being good at maths; masculinity; high intelligence; and middle/upper-*classsness*. Moreau *et al.* (in press) also found that 14/15 year old school students differentiated between stereotypical representations of mathematicians (who are short haired geniuses) and scientists, who have long, wild hair ('scientists have crazy hair'). Unsurprisingly, this image was not seen as an attractive or desirable identity by many students, especially not girls who wanted to look 'beautiful' instead:

'I wouldn't want to be a scientist because I don't want to find these like dead bodies and bones and … ugh! And then I wouldn't like to have big grey frizzy hair … because all scientists seem to have these caps on like bald heads and they have like [inaudible] and I don't want to look like that, I want to look beautiful'

(Girl, Inner City Elementary)

Such findings chime with other studies, in which Elementary and secondary school girls report enjoying science but cannot imagine themselves as scientists (e.g. Baker & Leary 1995; Jenkins & Nelson 2005; Research Councils UK 2008).

We would hypothesize that the dominant popular association of 'boffin'/ egghead identity with science will be undesirable (and require negotiation) for any girls who are invested in the construction of conventional (heterosexual, gender-traditional) femininities, but racialised and classed discourses of femininity would suggest that this may be especially undesirable or problematic for particular groups of girls whose identities (e.g. as non-white and/or working-class) are not typically associated with 'boffin' identity. For instance, research demonstrates how popular working-class (especially white working-class) discourses of femininity may not sit easily with notions of academic achievement (as compared, for instance to middle-class discourses around the 'blue-stocking') and how some of these constructions draw particularly heavily on certain embodied practices around 'glamour' (Archer *et al.*, 2007; Skeggs 1997) and sexuality (Renold 2005). This is not to say that middle-class girls do not experience tensions in balancing a 'desirable' femininity with academic achievement (cf. Reay 2001; Renold 2005), but that they have comparatively more discursive resources available to them to navigate this identity dilemma, given the popularly perceived congruence between academic achievement and middle-class femininity. For many working-class girls, a science identity may seem unintelligible (Butler 1990) and completely incompatible with the versions of femininity that they recognise as culturally desirable and acceptable. In other words, to imagine oneself into a space of being, young people need to be able to 'take up a science identity that can be recognised and accessed by others' (Calabrese Barton & Brickhouse 2006: 224).

The interplay between discourses of femininity, sexuality, achievement and science constitutes a space for analysis that we hope to pursue further as our study develops. Our conceptual starting point is that if high achievement and 'effortless brilliance' tend to be constructed as masculine, then high-achieving girls are required to engage in a form of identity work that involves the negotiation of an acceptable form of femininity (see Francis *et al.*, 2009 in the context of high-achieving students in the UK). In the case of science, this is heightened further, due to dominant constructions of science as a masculine. The ability for girls to navigate a successful (achieving) science identity will be overlaid further by social class and ethnic identities – being potentially slightly more congruent for middle-class girls (for whom dominant notions of 'acceptable' academic femininity tend to be linked with the suppression of sexuality, Renold 2005; Renold & Allan 2006; Skelton & Francis 2008). Ethnic identities will provide yet another crucial layer, or lens, for analysis. Whilst whiteness may be aligned more closely with the image of 'the scientist' in popular discourse (and hence may be a potentially congruent identity discourse), evidence suggests that the perceived 'respectability' and acceptability of a science identity may be constructed differently among ethnic collectivities (e.g. see Archer & Francis 2007 in the case of the British Chinese). The interplay between race, class and gender may mean that some families and collectivities may recognise and espouse versions of acceptable or respectable femininity which (for girls or young women at least) may render science as a more acceptable identity (for instance, due to its 'status' and the associated discursive repression of sexuality).

Despite the potentially positive associations that might be expected to follow from being identified as highly intelligent by virtue of taking up a science identity, as Epstein *et al.* (2010, in press) highlight in relation to mathematics, boffin identities reside dangerously close to 'geek' (or nerd) identities – a stigmatised social/learner identity that many children seek to avoid. We would suggest that the children's constructions of the scientist as boffin indicate that, as they get older, a science identity will come to operate as a pariah identity (Francis 2009) within the classroom - only a few students will be willing to 'risk' or embrace the identity due to the negative weight that it carries in popular identity terms. Its boffin associations and incongruence with popular/desirable forms of contemporary masculinity and femininity (especially working-class configurations) make it a potentially risky identity, being closely associated with markers of an 'uncool' identity.

Francis *et al.* (2009) argue that if high achieving pupils are to also be popular (and resist being positioned by their peers as boffins) they have to mobilise certain embodied capitals (notably physical attractiveness and fashion and or style) and conform to performances of dominant (conventional) gender identities (e.g. being sporty for boys and being 'girly' and coquettish for girls). Brickhouse & Potter (2001) describe the case of Ruby, an African American girl in their longitudinal US study, who had to engage in sustained identity negotiations to balance her achievement and participation in a competitive computing programme with an acceptable femininity. Ruby attempted to achieve this by balancing her 'masculine' performances of achievement (and achievement in a traditionally male sphere) with her performances of hyper-femininity (e.g. doing modelling and cheerleading). This was not easy, as detailed by her 'struggle to construct a liveable identity in a competitive computing programme in which she desires computing competence but does not desire other aspects of the central image of the computing program' (Brickhouse & Potter 2001: p.971). Thus, it seems likely that if an adolescent student is to embrace a science identity they must either inhabit the position of pariah (the socially derided 'geek') or possess the requisite embodied capitals to also convincingly perform dominant hetero-masculinity/femininity.

The Defence of Science as Masculine: ('fashion and science don't mix')

Drawing on the data from this study, we have argued thus far that taking up a science identity may be undesirable for many groups of young people but may become particularly problematic for girls (especially working-class girls) as they progress through compulsory (and by extension, we imagine, post-compulsory) education. In this final section we wish to highlight how, in the case of girls' scientific identities, boys do not play a silent or passive role in this process. This is reflective of how discourses are not external, objective structures (that exist 'out there' in society) but are active – they are constantly taken up, resisted or embraced and re-worked. The exclusion of girls from a high-status (albeit contradictorily configured) identity and field such as science is part of the patriarchal dividend – a state of affairs from which boys or men may benefit more generally. In this respect, it was not surprising that we found evidence of some boys making their own active investments in reproducing and policing the boundary of science (arguing that it is or should be a male preserve). This is encapsulated in the following extract, in which a group of boys suggest that girls are not 'naturally' into science because 'fashion and science don't mix'. The boys argued that boys are better at science, explaining that the scientists they know are all men ('cos my uncle's a scientist and he's a boy'; Newton, Einstein and Edison were also cited).

One of the boys also suggested that girls 'have no confidence' in science and this was due to their preoccupation with 'their nails chipping when they're doing the experiments'.

> *Boy:* *I don't think girls would make good scientists or like you know inventors and that, because they aren't usually interested in science mostly. If a girl is yeah, they would become famous like … there might be a girl that invented something - is there?*
> *Int:* *Mm.*
> *Boy 2:* *Yeah yeah. They mostly care about fashion. If they put everything into it, but most girls these days care about fashion and their trousers (inaudible)*
> *Int:* *Couldn't [girls] care about fashion and science?*
> *Boy 2:* *No they wouldn't, because fashion and science don't mix.*
> *Boy 3:* *Your nails could get chipped.*
> *Boy 1:* *I can add to that. Yeah, if they like … in science … cos most scientists wear glasses and girls these days care about fashion, and glasses aren't in fashion.*
> *(Inner City Elementary, boys)*

The above comments were made by an all male discussion group and it was notable that none of the mixed sex groups produced such accounts, presumably because the presence of girls would potentially have led to such views being challenged. But the above can also be read as part of these boys' everyday performances of 'doing boy'. This sort of 'cartoon sexism' is not uncommon in all boy groups (e.g. see Archer 2003a/b) and often tells us more about the ways in which boys discursively 'jockey for position' with one another (e.g. by articulating controversial or socially 'risky' views, or by adopting extreme or hegemonic viewpoints) than about their substantive views on gender equality. What is interesting here, however, is that science is recognised and deployed as a powerful resource for negotiating gendered subject positions. The boys all 'know' that science is popularly configured as masculine and as high status and is hence something that, as boys, they would have a vested interest in claiming (as 'for boys'). They recognise the ways in which science is popularly positioned as antithetical to femininity and they are able to draw on dominant stereotypes around femininity to question its viability as an identity discourse for 'real' girls (it is rendered acceptable only for unfashionable girls who do not 'care' about their appearance, i.e. challenging conventional notions of popular or desirable femininity as compatible with science). This exchange thus alerts us to the issue that if, as educators, we wish to attract more girls into science then we will need to focus our attention as much on popular or dominant constructions and performances of masculinity (and the ways in which boys may defend and claim science – and hence challenge and resist such interventions) as we might femininity.

Conclusion

In this paper we have identified and discussed a key dilemma for science education, namely that children can report enjoying science (e.g. they may find it fun, exciting, important and interesting) but they may still see it as 'not for me' and choose not to study it at higher level (Jenkins & Nelson, 2005). We conducted our analysis of children's discussion group talk through the lens of identity, noting how constructions of science and identity are circumscribed by social class, ethnicity and gender. We detailed how, even at this young age when children are mostly enthusiastic about science, some aspects of a 'science identity' are beginning to be ruled out as not only undesirable but even 'unthinkable', and other aspects are understood as possible or desirable only under certain identity conditions. In other words, beneath the broad brush general enthusiasm for science expressed by these children (independent of gender, ethnicity and social class), we can excavate the germination of (gender, ethnic, class) distinctions that will come to be solidified in later years. Our analytical distinction between 'doing' and 'being' provided an entry point to understanding and explaining this disjuncture.

The children's discursive demarcation between school science (as 'safe') and 'real' or adult science (as 'dangerous') highlights a real dilemma for educators: reworking school science in a way that would be more attractive to hegemonic masculinity (assuming this is even possible) might increase the interest and engagement of some boys but would be undesirable in that it would alienate girls and other boys and, given the inherent tensions between 'laddishness' and schooling, may well be unsuccessful even with its target group. The disjuncture we have identified between 'doing' and 'being' would also lead us to question the utility of such an approach. Indeed, Author 3 and Author 4 (2008) have argued, for instance, that what is required is a new vision of science education, not only of what we know and how we know, but also what kinds of careers science affords – both in science and from science – and why these careers are personally fulfilling, worthwhile and rewarding.

We also suggested that subtle differences between children's nature of engagement with out-of-school science also contain indicators of future distinctions (particularly classed distinctions) in terms of patterns of achievement and engagement in science. This suggests that a focus on reforming school science alone may not be sufficient if we are to broaden its appeal.

Finally, we would suggest that the content of the 'being a scientist' construction (in terms of science as hard/brainy; science as natural interest; scientist as boffin) have enabled us to tease out the complex interplay of discourses of gender, sexuality, ethnicity and social class within children's everyday constructions of science. Our analyses lead us to identify a conundrum in that, in its present form, science appears to be constructed as 'too feminised' for (many) boys and 'too masculine' for (many) girls. This appears to constitute an impossible position – can science ever appeal to all constituencies as a viable identity? This may point to the need to work with multiple visions of science – a position that in itself suggests a need to disrupt dominant discourses around science and the identity of the scientist. It also impels us to consider how we might bridge the gap between children and young people's everyday identities (those that are experienced as desirable, authentic and conveying status within their daily fields of interaction) and the identities and messages conveyed by school and 'real' science. Our analyses suggest that intelligible gender identity performances within one field (e.g. home, peer culture) may be incompatible with others (e.g. science). In particular, a science identity as it is popularly configured appears unintelligible for some children and young people due to its dominant gendered, raced and classed configuration.

Our analyses contribute to understanding the complex identity processes that may underlie the deep-seated, often trenchant, resistance that many interventions, designed to increase engagement and uptake of science among young people, have encountered. Whilst many of these interventions have been carefully and thoughtfully designed by a range of appropriate experts and practitioners, evaluative evidence indicates that even the 'best' interventions may still be resisted by pupils and/or enjoyed by those involved but make little or no difference to pupils continuing with science (e.g. see Carlone 2004; Solomon 1997). It is from this platform that we hope to be able to move forward to identifying how we might be able to interrupt dominant identity patterns of (dis)identification in relation to science in the future.

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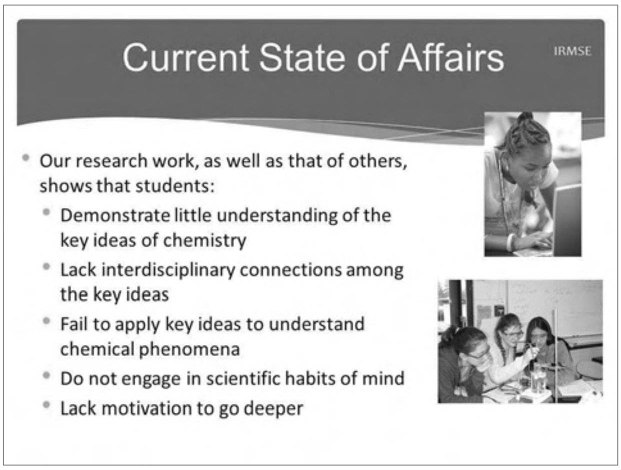
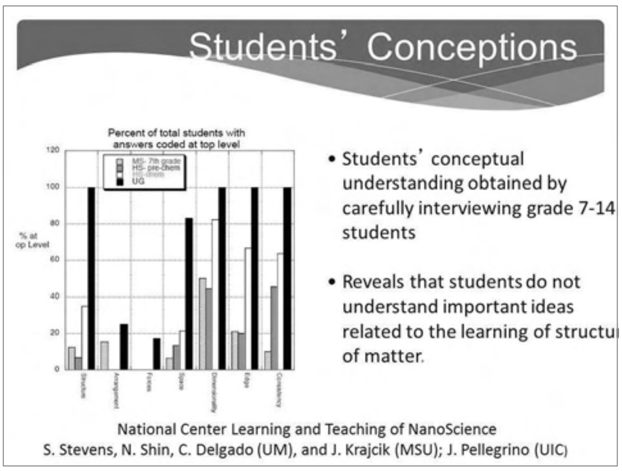
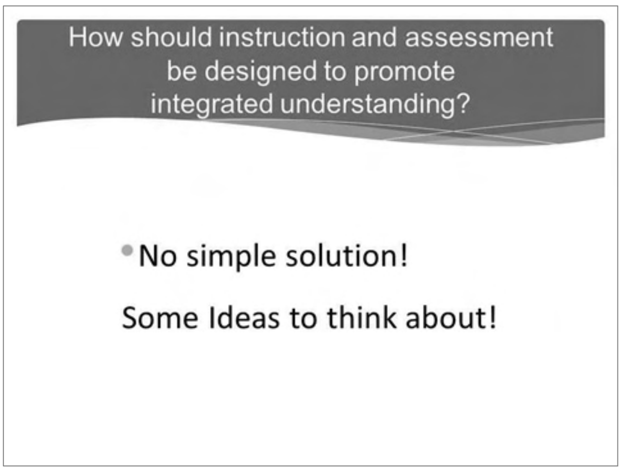
- Invited Speech 6
- Date: Thursday, October 27, 2011
- Time: 09:00 ~ 10:00
- Room: #3 (1F)
- Chair: J. Steve Oliver (University of Georgia, USA)

SUPPORTING STUDENTS' INTEGRATED UNDERSTANDINGS OF BIG IDEAS AND SCIENTIFIC PRACTICES ACROSS TIME

Joseph Krajcik
University of Michigan, USA







Four Ideas to Ponder

- Learning Progressions
- Big Ideas
- Scientific Practices
- Linking Big Ideas and Scientific Practices

First Idea to Ponder: Learning Progressions

- Research-based descriptions of how students build their knowledge and gain more expertise and sophistication of key ideas over time

Learning Progressions Built Upon Three Ideas

IRMSE

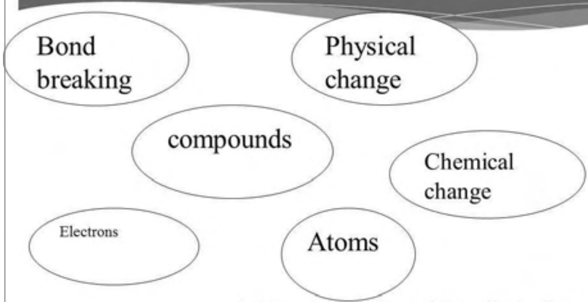
1. Engaging prior understandings
2. Building conceptual frameworks
3. Learning builds over time

Engaging prior understanding

IRMSE

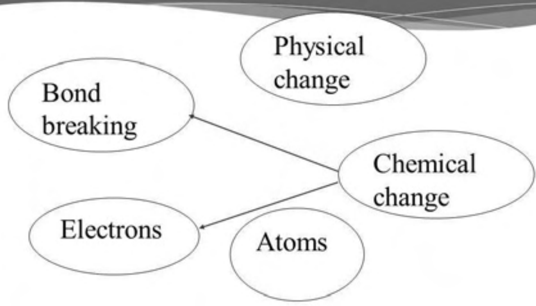
- New understanding is constructed on a foundation of existing understanding and experiences
- Learners connect new ideas to previous ideas to construct understanding
- Although students are continually introduced to new concepts, unless these new ideas connect to their existing ideas, learners do not build integrated understanding.

A graphical illustration of understanding Little, if any understanding

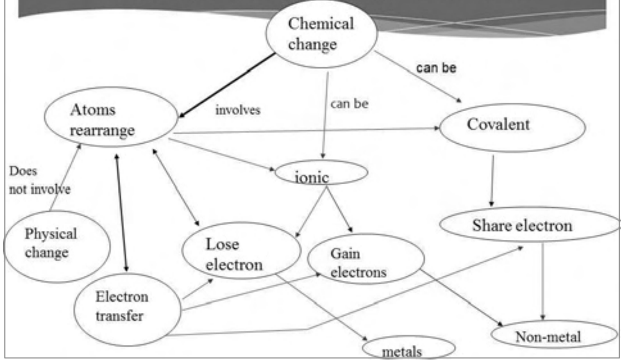


Learners cannot use ideas for further learning or problem solving.

Thin understanding: Some connections between ideas with potential to make new connections.



Integrated Understanding: new knowledge and prior knowledge are connected and related to create organized knowledge frameworks



Building Conceptual Frameworks

IRMSE

- Guide
  - problem solving
  - making observations
  - organizing and structuring new information

Learning Builds Over Time

- Learning develops as a continuous process across time
  - New understanding is constructed on a foundation of existing understanding and experiences
- Learning does not occur in linear, discrete steps
- Learning difficult ideas takes time and often comes together as students work on a task that forces them to synthesize

Second Idea to Ponder: Big Ideas

IRMSE

Learning is facilitated when new and existing knowledge is structured around the big ideas of the discipline

Criteria for "Big Ideas"

- Explanatory power within and across disciplines
- Powerful way of thinking about the world
- Building blocks for further learning
- Necessary for intellectual participation in making individual, social and political decisions regarding science and technology

Some Contenders for Big ideas

Particle Theory Of Matter

Equilibrium

Plate Tectonics

Biological Evolution

Chemical reactions

Earth Systems

Ecology

Forces

Energy

Think of the big idea as all the connections you form in your mind when you think of any one of these ideas

A Big Idea: Particle Nature of Matter

The existence of atoms, now verified by observation with modern instruments, is a model that can explain both qualitative and quantitative observations about matter. Matter can be understood in terms of the types of atoms present and the interactions both between and within atoms. The states, properties, and reactions of matter can be described and predicted based on the types, interactions, and motions of the atoms within it. Chemical reactions, which underlie so many observed phenomena in living and nonliving systems alike, conserve the number of atoms of each type but change their arrangement into molecules.

(Modified from the K- 12 Framework for Science Education, NRC 2012)

A Big Idea: Biological Evolution

Biological Evolution: changes in the traits of populations of organisms over time and the factors that account for species' unity and diversity alike. It begins with a discussion of the converging evidence for shared ancestry that has emerged from a variety of sources. It examines how variation of genetically-determined traits in a population may give some members a reproductive advantage in a given environment. This natural selection can lead to adaptation, that is, to a distribution of traits in the population that is matched to and can change with environmental conditions. Such adaptations can eventually lead to the development of separate species in separate populations. Finally the idea examines the factors, including human activity, that affect biodiversity in an ecosystem, and the value of biodiversity in ecosystem resilience.

(Modified from the K- 12 Framework for Science Education, NRC 2012)

Big ideas provide a framework for long-term development

IRMSE

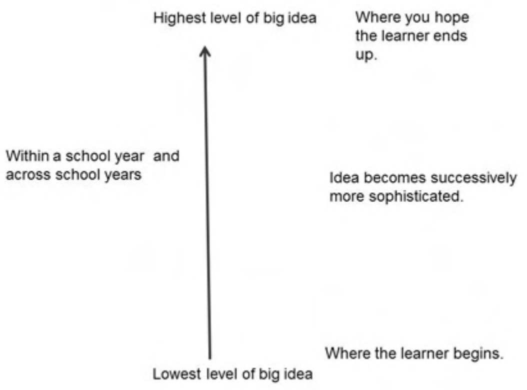
Big ideas can be revisited and built upon throughout K-16 schooling, so that knowledge becomes progressively more refined, elaborated

Developing Understanding Over Time

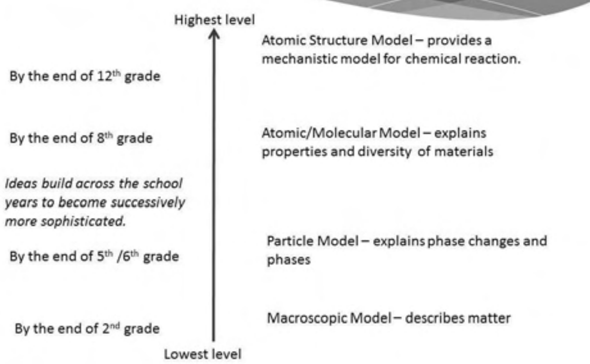
Learning progressions

- Describes how students progress from less to more sophisticated knowledge in a field and the instruction necessary to achieve this growth
- A sequence of successively more complex ways of thinking about how a big idea develops over time
- Consider how ideas build upon each other to form more complex practices or ideas
- Are not developmentally inevitable. Rather they depend on instructional sequences to support greater student understanding

Generic learning progression



Progression for Core Idea: Structure of Matter



By the end of grade 2: Structure of Matter

Descriptive Model: Matter exists as different substances, and many of them can be either solid or liquid, depending on temperature. Substances can be described and classified by their observable properties, by their uses, and by whether they occur naturally or are manufactured. Different properties are suited to different purposes. A great variety of objects can be built up from a small set of pieces. Objects or samples of a substance can be weighed and their size can be described and measured.

(Modified from the K- 12 Framework for Science Education, NRC 2012)

By the end of grade 5/6: Structure of Matter

Particle Model: Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. For example, a model showing that gases are made from particles that are too small to see and are moving freely around in space can explain many observations including: the impacts of gas particles on surfaces and on larger particles or objects, and the appearance of visible scale water droplets in condensation, fog, and, by extension, also in clouds or the contrails of a jet. The amount of matter is conserved when it changes form, even in transitions in which it seems to vanish. Measurements of a variety of properties can be used to identify particular substances.

(Modified from the K- 12 Framework for Science Education, NRC 2012)

By the end of grade 8: Structure of Matter

Atomic/Molecular Model: All substances are made from some 100 different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. Pure substances are made from a single type of atom or molecule; each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. Solids may be formed from molecules, or they may be extended structures with repeating subunits. The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

(Modified from the K- 12 Framework for Science Education, NRC 2012)

By the end of grade 12: Structure of Matter

Atomic Structure Model: Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. Stable forms of matter are those in which the electric and magnetic field energy is minimized. A stable molecule has less energy, by an amount known as the binding energy, than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.

(Modified from the K- 12 Framework for Science Education, NRC 2012)

Third Idea to Ponder: Scientific Practices

The multiple ways of knowing and doing to explore the natural world

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Developing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information



Content (scientific ideas) is not enough!

- Understanding content is inextricably linked to engaging in practices. Simply "consuming" information leads to declarative, isolated ideas.
- Science is both a body of knowledge and the process that develops and refines that body of knowledge. Understanding both the ideas and process are essential for progress in science.
- The learning of science is similar: students cannot learn one without the other.

Fourth Idea to Ponder: Link content and scientific practices together

- Not separate treatment of "content" and "inquiry"
- Curriculum materials need to do more than present and assess scientific ideas – they need to involve learners in using scientific practices to develop and apply the scientific ideas.

Big Ideas and Scientific Practice must Develop Together!

Highest level of big idea and scientific practice

Where you hope the learner ends up?

Within a school year and across school years

Ideas become successively more sophisticated. How do the ideas build on each other?

Where do students begin?

Lowest level of big idea and scientific practice

How should instruction and assessment be designed to promote integrated understanding?

No simple solution!

1. Need to design instruction and assessments with respect to learning progressions
2. Big ideas and scientific practices need to link and grow together

Case Study: the IQWST Project

IQWST: Investigating and Questioning our World through Science and Technology

- A collaboration to improve the teaching and learning of science at the middle school level by developing the next generation of curriculum materials.
- Interdisciplinary Team
- Joe Krajcik: Michigan State University
- LeeAnn Sutherland: University of Michigan
- Brian Reiser: Northwestern University
- David Fortus: Weizmann Institute of Science

Published by:

Sangari Global Education

The Next Generation of Science Learning Environments

IRMSE

- Utilizes a coherent approach
- Question driven (driving questions)
- Uses learning goals
- Applies what we know about student learning
- Supports students in developing understandings of the big ideas of science
- Engages students in complex tasks
- Uses evidence and reasons to explain phenomena

IQWST Approach: Curriculum Coherence

- Curricular coherence: the alignment of the specified ideas, the depth at which the ideas studied, and the sequencing of the ideas within each grade and across the grades
- Curriculum coherence leads to integrated understanding in learners
- Most traditional science textbooks and instruction do not support deep, integrated student learning due to their lack of coherence

Development of Science Ideas: What typically happens

IRMSE

	Physics	Chem	Earth Science	Life Science
6th				
7th	particle nature of matter			
8th				
Student Understanding	Little understanding			

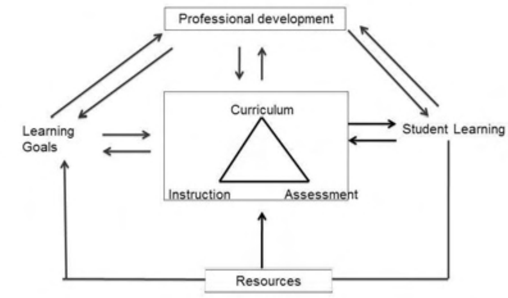
What happens in IQWST

	Physics	Chem	Earth Science	Life Science
6th				
7th	particle nature of matter			
8th				
Student Understanding	Integrated Understanding			

Strategies for Curriculum Coherence

- Some general principals
  - Selecting key learning goals that build on each other
  - Coordination between content learning goals, scientific practices, and curricular activities within a project-based framework
  - Coordination among project-based units that support multidisciplinary connections
- Some specific strategies
  - Activate and use students' prior knowledge and experiences
  - Make explicit links to key ideas
  - Make explicit how ideas help respond to driving questions
  - Use and link core ideas to explain other disciplinary ideas

The Importance of Learning Goals



Learning goals need to be a blend of big ideas and scientific practices

Modified from Systems for State Science Assessments NRC, 2005

Linking Core Ideas and Practices Together: Create Learning Performances to Specify Learning Goals

- Why use learning Performances?
  - Science standards are declarative statements of scientific ideas. They do not articulate "knowledge in use".
  - Using "know" or "understand" is too vague
  - We conceptualize understanding science as embedded in practice and not as memorizing static facts.
- What are Learning performances?
  - Learning performances define, in cognitive terms, the designers' conception for what it means for learners to "understand" a particular scientific idea
  - Learning performances define how the knowledge is used in reasoning about scientific questions and phenomena

Developing Learning Performances

Content × Scientific Practice → Learning Performance

Content	Practice	Learning Performance
Atoms and molecules are perpetually in motion. In gases, the atoms or molecules have still more energy and are free of one another except during occasional collisions.	Models are often used to think about processes that happen… too quickly, or on too small a scale to observe directly…	Students create models of a gas at the molecular level showing how the gas takes the shape of its container.

The IQWST Approach

IRMSE

- Serves as a testing ground for the effect of the proposed curricular coherence and sequencing of big ideas in science on student learning
- One coherent strand: the chemistry sequence
- Focus on three highly related and increasingly sophisticated chemistry big ideas:
  - the particle nature of matter,
  - the nature of chemical reactions,
  - the repeated transfer of matter between organisms and the environment (carbon cycling)

Research Questions

Research questions:

1) How do the three chemistry units, as taught in the specified sequence, affect middle school students' understanding of core chemistry ideas?
2) How does curriculum coherence affect student understanding of chemistry both within and across the middle grades?
3) Do student outcomes designed to measure their understanding of chemistry concepts vary by teacher?

Sung-Youn Choi, Joi Merritt, Kathryn Drago, LeeAnn Sutherland & Joe Krajcik

Curriculum Units

IRMSE

- 6th grade unit
  - **Particle model of matter**, properties and states of matter.
- 7th grade unit
  - Build upon their understanding of the particle model of matter
  - Properties of matter and **chemical reactions** at the macroscopic and microscopic levels.
  - Conservation of matter
- 8th grade unit
  - Build upon their understanding of the particle model of matter, chemical reactions, conservation and energy
  - Photosynthesis and respiration (carbon cycling)

IQWST Curriculum

- Designed to help students build understanding of science ideas within and across units
- Each unit is 8-12 weeks duration

Grade Level	Science Strand			
Sixth Grade	**Physics** *Can I Believe my Eyes?*	**Chemistry** *How Can I Smell Things From A Distance?*	**Biology** *Where Have All the Creatures Gone?*	**Earth Science** *How Does Water Shape Our World?*
	Light, its role in sight, and its interaction with matter	Particle nature of matter and phase changes	Survival: From organisms to ecosystems	Water and rock cycles
Seventh Grade	**Chemistry** *How Can I Make New Stuff from Old Stuff?*	**Physics** *Why Do Some Things Stop While Others Keep Going?*	**Earth Science** *How Is Weather Predictable?*	**Biology** *What's Going On Inside Me?*
	Chemical reactions and conservation of matter	Transformation and conservation of energy	Surface and atmospheric processes behind weather and climate	Biological organization and development: Cells to systems
Eighth Grade	**Chemistry** *Where Do I Get the Energy to Do Things?*	**Earth Science** *What Will Earth Look Like in the Future?*	**Biology** *Why Do Organisms Look the Way They Do?*	**Physics** *How Will It Move?*
	Chemical reactions in plants and in our bodies	Large-scale geological processes on Earth	Heredity and Natural Selection	Laws of Motion

The Study

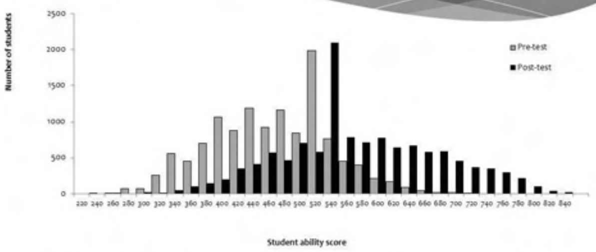
IRMSE

- Data sources: Pre/posttests
  - 15 multiple-choice questions and 3 open-ended, constructed-response items
- Data Analysis
  - Paired samples t-test
  - General linear model for repeated measures
- Participants
  - a cohort of approximately 3,000 students moving through middle school in four states form 19 schools
  - 25 6th grade teachers
  - 24 7th grade teachers
  - 9 8th grade teachers

IQWST Field Study Design

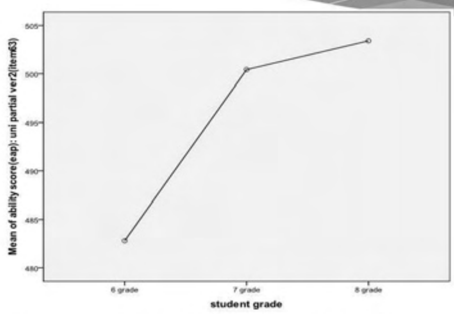
	Year 1 of field trial	Year 2 of field trial	Year 3 of field trial
6th grade	Cohort 1	Cohort 2	Cohort 3
7th grade		Cohort 1	Cohort 2
8th grade			Cohort 1

Research Question 1: Student Learning Gains



Comparison of students' ability score using pre and post test data showed that students experienced significant learning gains after participating in each of IQWST chemistry units This finding supports our hypothesis regarding the important of curriculum coherence.

Research Question 2: Student Understanding Across Grade Levels



Student Ability Scores Across Grade Levels: Statistically significant difference between 6th- 7th and 6th- 8th; no difference between 7th-

Research Question 3: Teacher Effect

Teacher' teaching experience in IQWST	N	Mean	SD	Diff. (N-E)
Novice (first year)	1750	489	91	-55**
Experienced teachers (more than two year)	371	544	108	
Total	2121	498	97	

Significant teacher affect by experience exists. Students of experienced teachers outperformed students of novice teachers.

Conclusions of the Study

- Students experience significant learning gains through the use coherent units
- Students who experience multiple years of coherent units develop higher abilities levels (especially across years 6th to 7th.
- Student attrition, teacher teaching experience, lack of fidelity to implementation and school effects might account for lack of significant growth between 7th and 8th grade.
  - A number of schools decided not to continue with the IQWST program in the third year because of changing administrative personal and pressure to teach to state tests.

Big Message: How should instruction be designed to support integrated understanding?

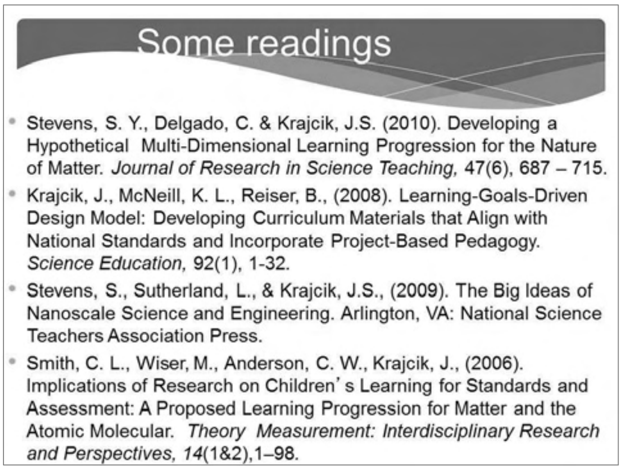
1. Need to design instruction and assessments with respect to learning progressions
2. Big ideas and scientific practices must develop together
3. The findings point to the importance of thorough professional development and teacher support during implementation.

Thanks to many

IRMSE

- IQWST and Learning Progression Groups at the University of Michigan
  - Drs. LeeAnn Sutherland, Soun-Youn Choi, and Joi Merritt, and Ms. Kathryn Drago
- National Science Foundation


IRMSE
Questions and comments
Contact: krajcik@msu.edu


Some readings
Stevens, S. Y., Delgado, C. & Krajcik, J.S. (2010). Developing a Hypothetical Multi-Dimensional Learning Progression for the Nature of Matter. Journal of Research in Science Teaching, 47(6), 687 – 715.
Krajcik, J., McNeill, K. L., Reiser, B., (2008). Learning-Goals-Driven Design Model: Developing Curriculum Materials that Align with National Standards and Incorporate Project-Based Pedagogy. Science Education, 92(1), 1-32.
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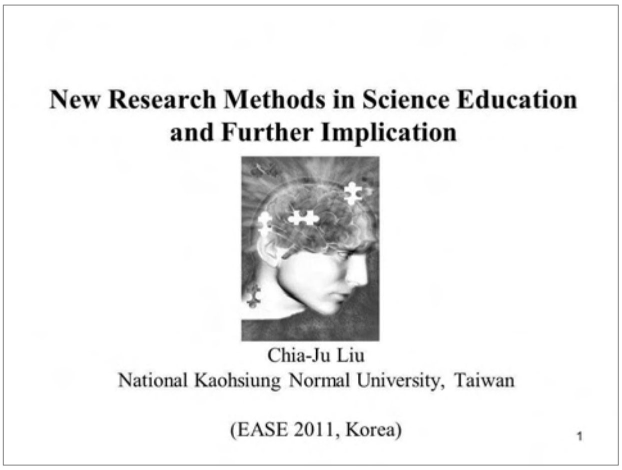
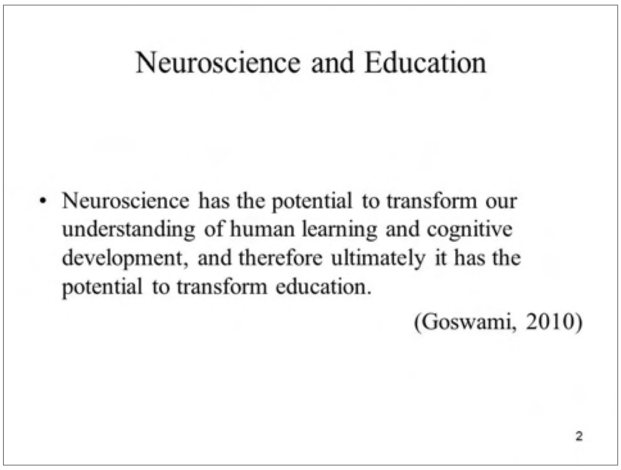
Smith, C. L., Wiser, M., Anderson, C. W., Krajcik, J., (2006). Implications of Research on Children's Learning for Standards and Assessment: A Proposed Learning Progression for Matter and the Atomic Molecular. Theory Measurement: Interdisciplinary Research and Perspectives, 14(1&2),1–98.

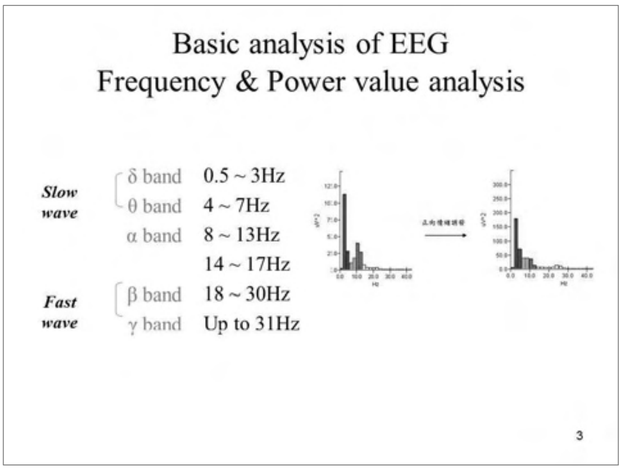
- Invited Workshop 3
- Date: Thursday, October 27, 2011
- Time: 15:40 ~ 16:40
- Room: #1 (1F)
- Chair: Bongwoo Lee (Dankook University, Korea)

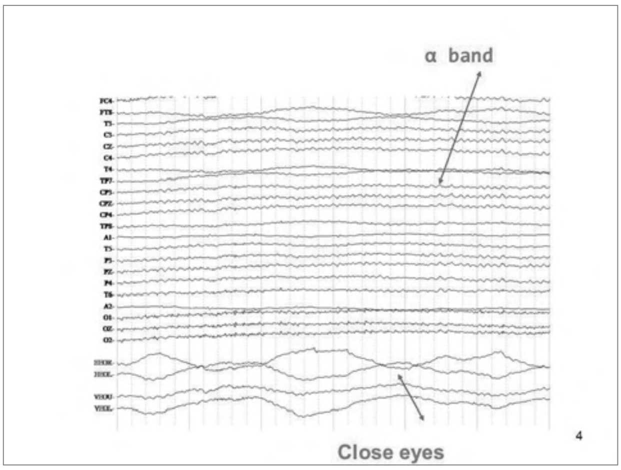
NEW RESEARCH METHODS IN SCIENCE AND EDUCATION AND FURTHER IMPLICATIONS

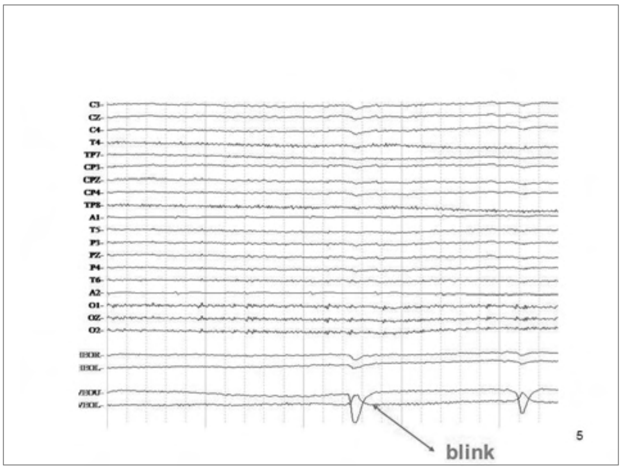
Chia-Ju Liu
National Kaohsiung Normal University, Taiwan

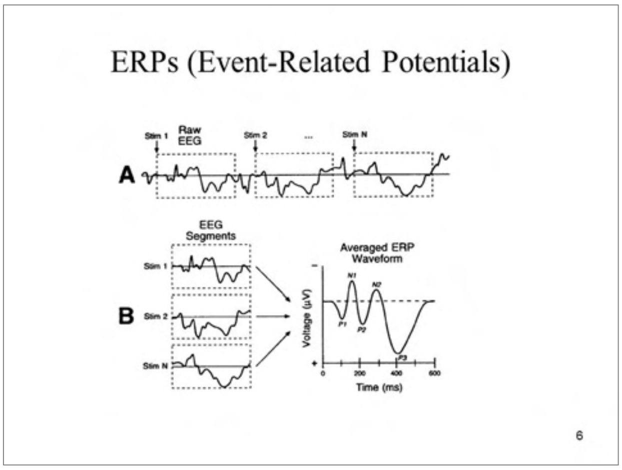


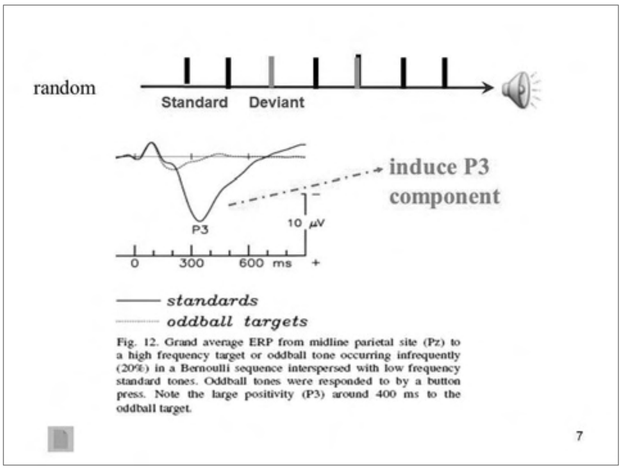


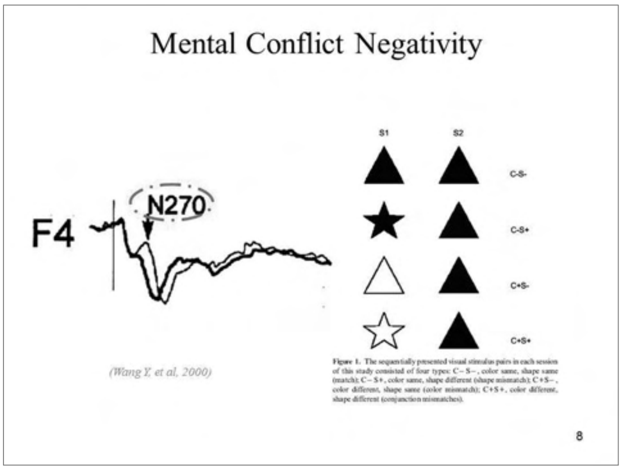












ERPs Research and Science Education

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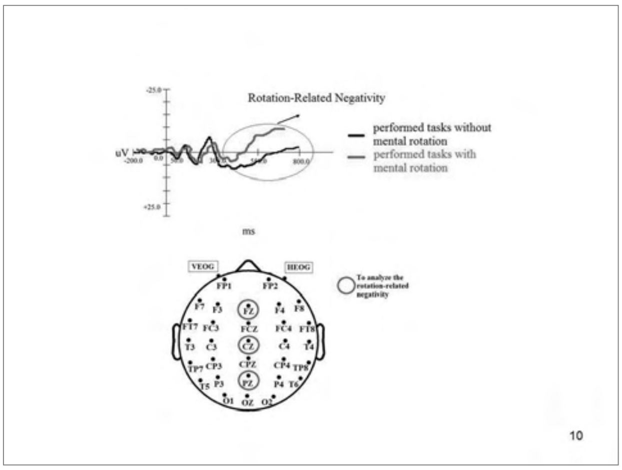

Experimental design

- Fifty university students major in chemistry (n = 50, 31 males, 19 females; Mean age ± S.D. = 20.9 ± 2.0 years) participated in the study.
- Chemical Structure Conceptual Questionnaire (CSCQ)
- ERP experiments included 2D geometric figures (2D figures), 2D chemical structures, 3D geometric objects (3D objects) and 3D chemical structures.
- Interview

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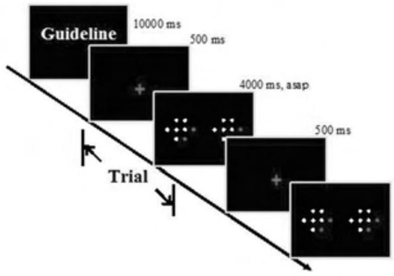
Experimental process



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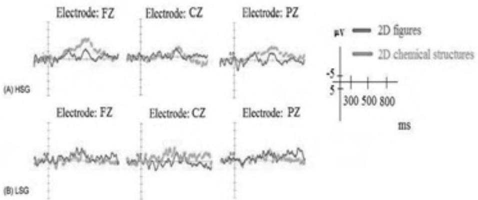

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Demonstration and Operation section

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Eye Tracking Research and Science Education

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Eye-Mind Hypothesis

- Eye-Mind hypothesis, that is, there is a correlation between what a person is looking at and what he/she is thinking.

  (Just & Carpenter, 1984)
- Based on this Eye-Mind hypothesis, eye movement could be studied to understand cognition.

  (Anderson et al., 2004)
- Elementary school students' problem solving strategies on solving concentration problems were explored.

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Concentration problems

- This study utilized a modified form of Noelting's (1980) ''orange juice test'' to investigate the relationship between students' perception of the concentration problems and the problem-solving strategies they used.
- These problems comprised three stages, and each stage consisted of comparing the taste of orange juice in two cups.
- In this study, the three stages were (I) intuitive stage, (II) concrete operational stage and (III) formal operational stage.

Stage	Example	Quantity relation: (a, b) vs. (c, d)
(I) Intuitive	(3, 4) vs. (2, 2)	$\{a<c, b<d \ \& \ a<b, c=d\}$
(II) Concrete operational	(1, 2) vs. (2, 4)	$\{\frac{m}{n}a=c, \frac{m}{n}b=d \ \& \ na \neq b, nc \neq d\}$
(III) Formal operational	(2, 7) vs. (3, 5)	$\{ma \neq c, mb \neq d \ \& \ na \neq b, nb \neq d\}$

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Participants

- 19 third-grade students (mean age ± SD = 9.0 ± .1) and 18 fifth-grade students (mean age ± SD = 11.0 ± .1).
- All students had taken and passed a visual acuity test, and their eye movements were calibrated on a computer screen prior to the test.
- After calibration, participants were presented randomly-generated stimuli and asked to verbally answer which one (A or B) had a higher concentration of orange juice.

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Experimental Design

- The materials were adapted from Noelting's ''orange juice test'' experiment. It consisted of three stages of problems: intuitive, concrete operational, and formal operational stages.
- Each problem was displayed in the form of iconic and symbolic representations.

Iconic form

Symbolic form

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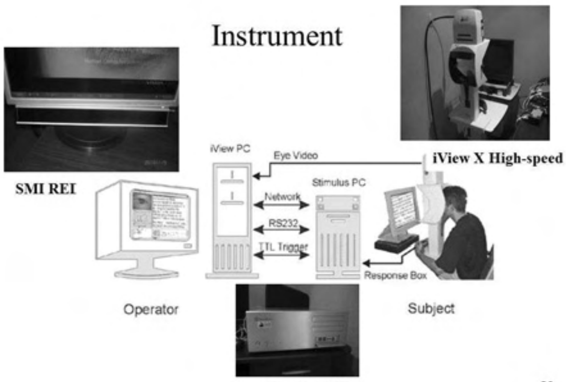
Instrument



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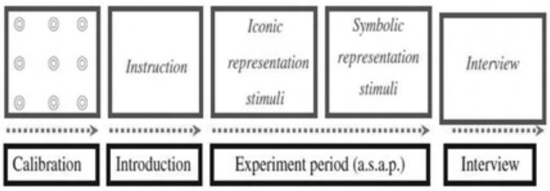
Experimental Procedure

- The procedure of this study involved four phases:



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Indicators of Analysis

- Correct rate (CR): the rate of solving problems successfully
- Eye-movement data: fixation, saccade, blink, scanpath
- Set up the Area of interest (AOI)
- Test the differences with statistical calculations

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The CR Reflect the Performance of Problem-Solving

- The analysis of variance showed a significant effect on stages of problems $F(2, 34) = 31.69$, $p = .05$, $\eta 2 = .651$
- No significant effect on the representational types $F(1, 35) = 2.33$, $p = .135$, $\eta 2 = .063$ or school year $F(1, 35) = 4.089$, $p = .05$, $\eta 2 = .105$.
- Thus, it can be concluded that students had different performance levels for solving problems because of the different stages of the problems.

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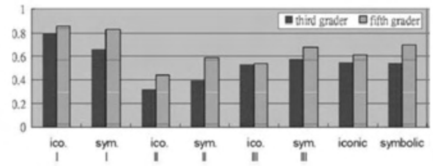
Result did not correspond to Noelting's conclusion

- Noelting's conclusion: concrete operational stage are easier than the formal operational stage for children.
- CR of concrete operational stage < CR of formal operational stage, particularly for third-grade students.
- Therefore, this study further analyzed the eye-tracking data to investigate the differences between students of different grades.



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The Eye-Tracking Data Reflect the Strategies of Problem-Solving

- The third grader spent more time solving problems than the fifth grader.
- Most fifth grader used numerical computation to solve problems while the third grader were more inclined to compare the quantities.
- This result corresponds to the developmental stages of the children.

Table 3 The difference in indicators between third graders and fifth graders

	Third-grade students Mean (SD)	Fifth-grade students Mean (SD)	t	p
Total fixation duration [ms]	4,788 (4,262)	3,770 (3,030)	7.285*	.000
Total saccade duration [ms]	431 (465)	450 (589)	−1.025	.306
Total blink duration [ms]	450 (895)	631 (1,261)	−4.594*	.000
Total time [ms]	6,050 (5,081)	5,060 (3,919)	4.209*	.000

* $p < .001$

Effective indicators of eye movement

- The time to solve problems displayed in symbolic representations was longer than in iconic representations.
- Representational types impacted students' thinking processes on how to solve problems.
- It was thus inferred that AFD and ABD are related to students' problem solving.

Indicators		Rep. types		Grades F	Rep. types F	Grades × rep. types
		Iconic	Symbolic			
AFD	G3	2,604(1380)	2,717(1488)	.039	6.16*	3.15
	G5	2,256(896)	2,922(1028)			
ASD	G3	204(90)	220(136)	1.069	5.052	.917
	G5	228(128)	272(127)			
ABD	G3	191(154)	247(192)	4.847*	9.713**	2.894
	G5	320(277)	512(474)			

* $p < .05$; ** $p < .01$

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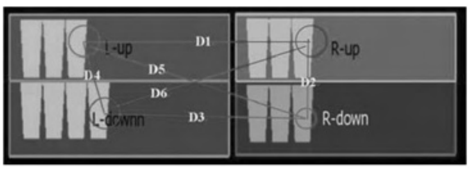
Shifting of AOI

- To investigate which strategy students used to solve problems, the numbers of fixation were analyzed with correlation statistics.
- Shifting of AOI was defined as six directions of fixating the picture.(D1~D6)



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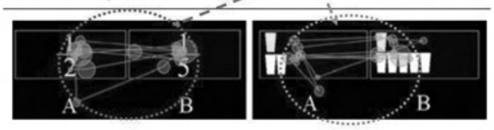
Scan path analysis

Stages	Rep. types	Third graders	Fifth graders
I	Iconic	D1–D3	D1–D3
I	Symbolic	D1–D3	D1–D3
II	Iconic	D2–D4	D2–D4
II	Symbolic	D1–D3,	D5–D6
III	Iconic	D1–D3, D2–D4	D1–D3, D5–D6
III	Symbolic	D1–D3	D5–D6



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Discussions and Conclusions

- Results from behavioral data revealed that the performances of problem solving are similar between third-grade students and fifth-grade students.
- Representational types appear to impact students' problem solving at different stages of the problems.
- Result from eye-tracking data found that fifth graders tended to use numerical computation when the problems were displayed in symbolic representations.
- These data indicated a longer duration of thinking while students solved problems displayed in symbolic representations than problems in iconic representations.

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Demonstration and Operation section

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Interesting Combination of Analysis

Voice
Eye Movement
EEG

(pilot study by Chia Ju Liu & Ken Tobin)

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Interesting Combination

- Three methods analyzed the research's emotion while he looked at the video about the meeting of teaching group.
- In the video, Viola talked to Ken and the talking will be analyzed.
- The transcript and duration of utterance were displayed below.

Turn	Speaker	Transcript	Duration of utterance
01	Viola	Um I'm Amanda Bickerstaff Um I I work at Bryne (0.7)	3.6s
02	Ken	Where do you live (0.2)	0.5s
03	Viola	Duranga (0.1) Westchester (0.2)	
04	Ken	Oh Ok (0.8) Where's that (0.8)	1.7s

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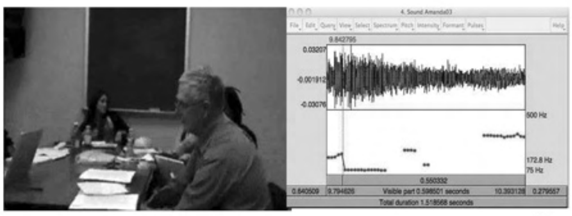
Analysis of Voice

- At the moment Amanda utters Westchester F0 is 173 Hz, F1 is 600 Hz and F2 is 1586 Hz. Most power is contained in F1 (1122 μPa2/Hz) followed by F0 (320 μPa2/Hz). The power contained in F2 was also non-zero (229 μPa2/Hz).



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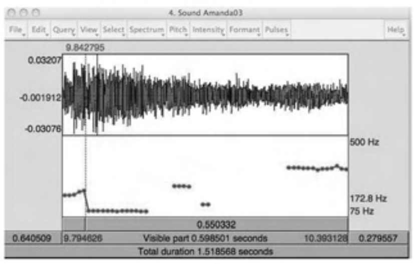
Analysis of voice

- The first six seconds of this video are of a neutral face. What follows is the vignette that is extracted by me from the video of our experiment. A the moment 9.840s, what can another analysis found?



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Eye Tracking analysis

- There were 5 fixation points and the fixation duration in each point was varied. The circle No. 8 was the start of eye tracking. The circle No. 12 was the fixation point at 9.800s.

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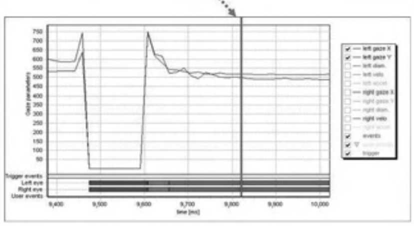
Line graph

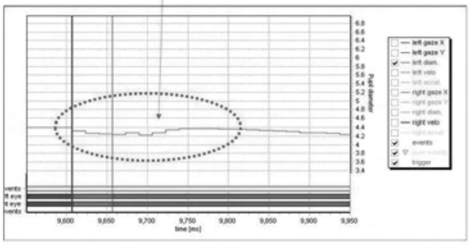
- There were large variations in the left-eye gaze positions. Data before and after 9.840s were analyzed because we did not find any difference of gaze position on eye tracking data at 9.840s



36

The variation of pupil diameter

- The graph shows the variation of pupil diameter from 9.6s to 9.8s while the research looked at the video.



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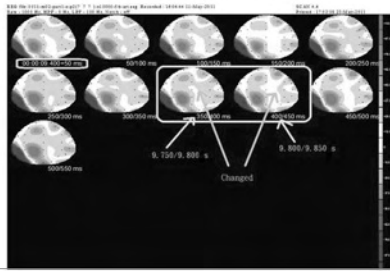
EEG analysis

- We inferred that something might have happened at 9.750s and influenced the participant's emotion.
- Actually, We suspected that Amanda's talk influenced the participant's emotion. The changes in emotion were detected by eye tracking (9.500s - 9.600s) and the average brain activities (9.750s - 9.800s).



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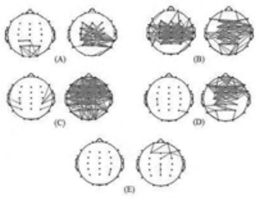
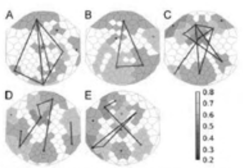
Mutual Information of EEG

- we used mutual information (MI) analysis of the EEG to try to discriminate the attention between normal aging and mild cognitive impairment patients.





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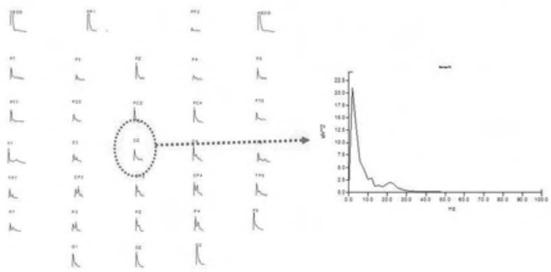
The whole brain power value of EEG



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Inference of pilot study

- Partala and Surakka (2003) indicated that auditory emotion-related cues could be utilized to modulate the user's emotional reactions.
- Hess (1972) indicated that empirical evidence has shown that the changes of pupil diameter are correlated with emotion.
- Eye-tracking technology would offer a possibility for unobtrusive monitoring of emotion-related reaction by the variation of pupil diameter.
- Furthermore, EEG data showed that the status of emotion was evoked at the same period of time when he looked at the video.
- We can say that he exactly provoked real emotion.
- (Ken Tobin & Chia Ju Liu, 2011)

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We can do it better!

- Clearly, some analytic technology of neuroscience to make contributions to educational research is extremely potential.
- We need to connect the bridge between neuroscience and education.
- Everyone should give yourself opportunities to do research by current available neuroscience techniques in education.
- Educational neuroscience technology will help us to uncover the 'box of brain' and understand outstanding educational problems.

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Thank you.

National Kaohsiung Normal University
Chia-Ju Liu
chiaju1105@gmail.com

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E·A·S·E

- Contributed Workshop 4
- Date: Thursday, October 27, 2011
- Time: 15:40 ~ 16:40
- Room: #2 (1F)
- Chair: Hisashi Otsuji (Ibaraki University, Japan)

1.

DEMONSTRATION ON CAUSE FOR SEASONS

Donghyun Chae
Jeonju National University of Education, Korea
✉ *donghyun@jnue.kr*

The cause for seasons is not easy for students to understand, even college students. Also, previous misconceptions are difficult to dispel (Valerie Frede, 2008). The author will create a new model. The model requires that students to measure 1) the different lengths of daylight of each season with a straight axis globe and tilted axis globe, and 2) different sun's elevations of each season with a straight axis globe and tilted axis globe.

- Contributed Workshop 5
- Date: Thursday, October 27, 2011
- Time: 15:40 ~ 16:40
- Room: #3 (1F)
- Chair: Gyoungho Lee (Seoul National University, Korea)

2.

A TINY TOOL TO DEMONSTRATE ENERGY CONVERSION BETWEEN LIGHT AND ELECTRICITY

Masafumi Watanabe, Masahiro Kamata
Tokyo Gakugei University, Japan
✉ *m101807y@st.u-gakugei.ac.jp*

In japan, junior high school students learn about energy conversion among different kind of energy such as mechanical energy, thermal energy, light energy, chemical energy and so on. If the students can experience both directions of energy conversion using the same (reversible) device, the concept of energy conversion will be very clear to them. From such a viewpoint, a simple and inexpensive tool to demonstrate energy conversion between light and electricity has been developed using two light emitting diodes. The tool generates electricity from light coming through two LEDs, stores it in a condenser (220μF), and emits light from one of the LEDs using the stored electricity for several seconds. Students understand that they are picking up light, storing it, and releasing it. The structure and the circuit of the tool are simple and no special techniques or tools are needed to assemble it. The cost of one set is low (far less than one US dollar), and therefore, students can make and use their own devices.

- Contributed Workshop 6
- Date: Thursday, October 27, 2011
- Time: 15:40 ~ 16:40
- Room: #4 (2F)
- Chair: Hyunju Lee (Ewha Womans University, Korea)

3.

THE MEANING AND THE SCOPE OF THE STEAM EDUCATION

Jean S. Chung
Korea Foundation for the Advancement of Science & Creativity, Korea
✉ *chung@chungbuk.ac.kr*

The STEM education initiated in the United States puts emphasis on the importance of four subjects, namely, science, technology, engineering, and mathematics. STEAM education, however, has a different aspect in that it puts emphasis on the integrated education as well as adding art to the existing list. In speaking of STEAM, the same word seems to stand for different meanings depending on the speaker. In many cases, discussion of integrated education has been proceeded within the context of sciences. The real environment of integration, however, would be made possible after all subjects are actively engaged under a common purpose. In this talk, the desirable direction of STEAM education and the scope of applying the integration will be discussed.

- Contributed Workshop 7
- Date: Thursday, October 27, 2011
- Time: 15:40 ~ 16:40
- Room: Computer Lab (2F)
- Chair: Prumuan Siripankaew (The Institute for the Promotion of Teaching Science and Technology, Thailand)

4.

UNDERSTANDING SCIENCE USING MATH AND EXCEL COMPUTER PROGRAM

Seung-Urn Choe
Seoul National University, Korea
✉ *suchoe@snu.ac.kr*

Mathematics is a language that describes natural phenomena. Since the introduction of adding and subtraction in elementary school, mathematics has been studied and practiced by every individual. However, even among the scientists, whose job are to explore the details of natural phenomena, and in education fields that proudly announce they study science, people are reluctant to use the language of mathematics in their works. This displays a tendency that the level

of mathematics we studied in school merely ends at solving textbook problems and fails to include its internal meaning and usages. In this presentation, the mathematics embedded in science will be illustrated and discussed using the excel program. Graphical and animated demonstrations will be presented to better understand mathematical expressions and the sensitivity of each variable in the mathematical expressions. The method we attempt to demonstrate in the presentation collaborates with math, science, and computer technology to aid the comprehension of each subject and is expected to create a synergy effect on education fields. Furthermore, it will show our learning ability improving when our rational thoughts are combined with the emotional activities.

- Science Demonstration 2-A
- Date: Thursday, October 27, 2011
- Time: 14:40 ~ 15:40
- Room: Main Room

1. SD2-A1

ATWOOD'S MACHINE

Jong Deok Chung*
Samhyun Girl's High School, Korea
✉ *chungjd53@hanmail.net*

Atwood's Machine, consisting of two different masses, hanging on a light string over a light, frictionless pulley, is hanging on a spring balance. When the masses are stop, how much does the scale indicate? And, When the masses are stop, how much does the scale indicate?

2. SD2-A2

INTERESTING ELECTRICITY

Jongwon Park, Jin-kuk Kim*
Chonnam National University, Korea
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Here, following three demonstrations will be shown.
1. Dielectric polarization : Wood rod can transfer the electricity! If conductor or insulator rod is placed between the charged material and electroscope, do you think the leaves in the electroscope move apart or not? Usually in the case of conductor, we can easily expect that the leaves of electroscope will move apart because of electrostatic induction by the motion of electrons inside the conductor. However, many people think that the leaves of electroscope will not be move apart in case of insulator because electrons inside the insulator can not move. In this demonstration, we will show that the leaves of electroscope move apart in case of insulator. This is because of dielectric polarization. In fact, this is the same reason why a plastic rod rubbed on fur attracts pieces of paper as the region of the paper closest to the plastic rod takes on an opposite charge to the plastic rod. **2.** Simple solar cell made by ordinary copper plates and salt water Semiconductor solar cell is usually made in the factory, therefore we can not see it's internal structure directly. However, we can make a solar cell easily by using ordinary copper plate. In this demonstration, we will show how to make copper solar cell, and you can observe that the copper solar cell is very sensitive to the strength of the light. **3.** Do you think LED can generate electricity using light? For scientific creativity, 'thinking reversely' is very useful thinking strategy. For instance, ordinary speaker which transforms electric signal into sound can be used as microphone which transforms sound into electricity. Then, do you think ordinary LED(Light Emitting Diode) which transform electricity into light can be used to generate electricity from the light? In this demonstration, we will give an answer about this question.

3. SD2-A3

FLUID PRESSURE, SURFACE TENSION, FRICTION

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1. Counter-intuitive demonstration of the dependence of fluid pressure on depth : To determine if students understand the relationship between air pressure and water pressure you may wish to present this counter-intuitive demonstration of the dependence of fluid pressure on depth. **2.** Counter-intuitive demonstration. The water floating in the air: After filling glass with some water, put paper on the top of the glass and make it upside down. Students know that the water in the glass doesn't flush because air pressure acts up. And what happens if you remove the paper which is on the top of the glass. Does the water pour from the glass?, Let's make the water in the glass not pour from the glass when the paper is removed through science principle of surface tension. **3.** The swing using friction between papers and papers: A strong friction occurs when each pages of the two books overlapped each other. This friction force is enough to lift a man. Let's make the swing using friction between papers and papers.

4. SD2-A4

SHOOT THE FLOATING BALL IN TURBULENCE WITH AUTOMATIC BAMBOO GUN

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Young-Shin Park
Chosun University, Korea

Clear Air Turbulence (CAT) is unable to be visually seen neither be easily detected by electronic device in the flight. In order to enhance the comprehension of CAT, Science center usually used air stream extracted from the tube to help a light ball floating in front of the exit of tube. Now, the air stream joins together after passing the arc- shaped side on the bar; the similar theory applies to the floating ball surrounded by air stream. When the air stream is bounced back by palm or flat panel upon the ball, that clashes with the up-going air stream, making the floating ball unstable. By using a hand-made automatic bamboo gun can help visitors easily understand and access the CAT-related phenomenon. Each automatic bamboo gun can be easily installed with the material kit by people within 10~15 minutes so that the course can be full of fun and enjoyment.

5. SD2-A5

CONFUCIUS OF A JAR, SIPHON TOYS, MAGNETIC GUN

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Following three physics demonstration will be shown : (1) Confucius of a jar, (2) Various Siphon Toys, (3) Magnetic gun.

6. SD2-A6

VACUUM EXPERIENCE, ELECTROMAGNETIC FORCE, MOMENT OF INERTIA

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As following three demonstration of physics, it will be shown that: (1) Vacuum Experience by utilizing a vacuum cleaner. (2) Observation the Change of mass due to Electromagnetic force : An experiment on the change of mass of the copper rod when a ring magnet is dropped along the copper rod. (3) The moment of inertia changes because of changing in Inter materials of sphere : Observation of differences when spheres which are same size and shape roll in slope inclined plane by changing inter materials of sphere.

7. SD2-A7

EARTH'S MAGNETIC FIELD, SIMPLE VOLTMETER

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1. Demonstration to observe the Earth's Magnetic Field : It's an experiment that checks the existence of the Earth's Magnetic Field using wire that flows current. Make solenoid form by winding up the wire several times. Next, link the galvanometer and the both ends of the wire. Observe induced current as shaking left and right, back and forth and up and down. Predict when Induced EMF is maximum according to shaking direction and forecast direction of the Earth's Magnetic Field. **2.** Demonstration of making simple voltmeter: It's a demonstration device which students themselves can study principle of voltmeter by making it using materials that can be bought easily such as clear glass, styrofoam ball, and Neodymium magnets.

8. SD2-A8

SONIC BOOM, GRAVITATIONAL ACCELERATION, ACCELERATION

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1. Sonic boom by a whip : Before the invention of a bullet weapon What was the fastest in the world? Is a whip. Please wielding a whip. Momentarily The cracker on the end of the whip will move at a speed faster than the speed of sound. Just this time, the sonic boom is created. Let's create a sonic boom with a whip. **2.** A paper cup be accelerating faster than Gravitational acceleration : In the absence of wind resistance, all objects fall to the ground with the same acceleration. But this device (This device consist of a paper cup and a ball.) makes the paper cup and the ball are fall, and the paper cup be accelerating faster than the ball. How can this be? **3.** Measure the acceleration : Why would an object the faster or slower? The reason is the force. Try force acting on an object. The object can be faster or slower. We will make the particular device to help to visualize the acceleration. Let's measure acceleration using this.

- Science Demonstration 2-B
- Date: Thursday, October 27, 2011
- Time: 14:40 ~ 15:40
- Room: Lobby

9. SD2-B1

UNDERSTAND THE 'ATMOSPHERE PHENOMENON'

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It would be very interesting experience if you can investigate the natural phenomenon with five senses only. Despite atmosphere phenomenon is closely connected to our lives, you cannot investigate it completely with only your naked eye, which makes students understand it difficult. Thus, you can make them more understandable the atmosphere phenomenon more easily in your classes with this experiment designed and shown through this science demonstration. Through this demonstration, you can see the structure of a cold front and a warm front at the same time. In addition, you can find out the formation of fronts. First, you need a clear water tank which is separated into two parts. Second, you attach a heat-sensitive film onto the water tank. Third, you pour some cold water and warm water into each part. Fourth, when you remove the partition, you will observe the color of the heat-sensitive film changed. Lastly, just imagine what you can observe from the films. According to the results, students can learn not only about the front and the frontal surface, but also the reason why the air climbs steadily on the frontal surface. The activities can be regarded as one of teaching tools, scaffolding students to understand the concept of 'front' by observing the slopes of cold and warm front as well as front surface and the reason of air rising on front surface.

10. SD2-B2

HOW TO MAKE COMET

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We need a slightly different approach in Earth science, because it has a massive scale and the place is off limited. Especially, Scientists are keeping a close watch on comets. By observing the movement of comets they can study the formation of the universe. But it is hard to find out the cycle of comets. Sometimes the cycle is too long to observe. That's why we always use close-up photo instead in classes. The activities can be regarded as one of teaching tools, scaffolding students to understand the concept of 'model comets'by using the similar ingredients and similar proportion. We would like to comparing the model comet with the real comet. According to the results, this activities can be a great help in educating students to understand comets. Also, students can get vivid memories not only they study.

11. SD2-B3

THE CHANGE OF FOUR SEASONS

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There are four seasons in Korea and the tilt of earth's axis is the reason for the seasons. This can makes the earth revolves around the sun. In general, many students have misconceptions about the change of four seasons. Because they knew it as a knowledge, So that students can't understand that there is an interrelationship between the tilt of earth's axis and the earth. The activities can be regarded as one of teaching tools, scaffolding students to understand the concept of 'changes of Energy. By using the simple test, we would like to see how the light from the Sun is spread out more on the surface of the Earth when it strikes the Earth at an angle. In this demonstration, you can use a heat-sensitive film to notice even a small change. The heat-sensitive film's color will be changed by incident angle. According to the results, this activities can be a great help in educating students to understand 'changes of Energy'. Also, students can figure out an interrelationship between the tilt of earth's axis and the earth.

12. SD2-B4

HOW TO MAKE FOSSILS?

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It is interesting that the fossilization processes are shown by simple tools and materials. The processes are consisted of preparation, fossil making procedures, and last forming. At first, the prepares are chemicals of alginate, paper cups, short stirrer of thin timber, gypsum powder(dried), and materials used to temporal fossil as shells, leaves, plastic fossil models. The making processes are as follows; 1) mixing alginate and water in a paper cup 2) temporal fossils drop into the cup 3) mixing water and dried gypsum powder 4) waiting during reaction 5) separating gypsum fossil from alginate 6) observation. On the basis of above fossil making procedures, we could understand the basic fossilization processes. And, it is expected that the procedures are raised strong curiosity on fossil making and past world.

13. SD2-B5

SECONDARY SCHOOL STUDENTS TO UNDERSTAND THE CONCEPTUAL CHANGE OF LUNAR PHASES

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The purpose of this study was to help the 3th grade in secondary school students to understand the conceptual change of lunar phases. (phase change of the moon) The experiment is based on the presumption that the whole classroom is the universe. We are going to assume that the class room as the Universe. After we explain the relative positions of the sun, moon, and earth We'll find out the results(effects) that if it can help the students' conception-forming experiences. Students can see the Moon and the Sun very easily in their daily lives. So, the conceptual change of Lunar phases is very familiar, especially in earth science. But, it is also one of the most difficult conception for many students to understand it. Sometimes even science teachers have misunderstanding many of the conceptions. Most student tend to learn all of it by heart. So, they can misunderstand the (conceptual change of lunar phases) in the equatorial region or in the southern hemisphere. (According to the results) The activities consisted of such concepts as: understanding the conceptual change of lunar phases, finding definition of compass point and the time of the moon's southing are the main activities.

14. SD2-B6

EFFECT OF ATMOSPHERIC PRESSURE

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The subject matter of this class is effect of atmospheric pressure. instructional objectives is understanding that we are always influenced by atmospheric pressure in their life. The teaching process is learning research group activities. process of experimentation are as follows. **1.** Dent the aluminum can with atmospheric pressure. **2.** and Dent the plastic container. **3.** and then students realize the magnitude of atmospheric pressure. **4.** and ask "why we can`t feel power of atmospheric pressure" **5.** lastly, students find example in everyday life. This can make students understand the concept of atmospheric pressure.

- **Oral Presentation 2-A**
- **Date: Thursday, October 27, 2011**
- **Time: 10:20 ~ 11:40**
- **Room: #1 (1F)**
- **Chair: Jinwoong Song (Seoul National University, Korea)**

1. O2-A1

SEARCHING FOR EFFECTIVE INSTRUCTION OF OPEN-INQUIRY: THE DIFFERENCES BETWEEN STUDENTS' AND TEACHERS' RECOGNITION OF THE DIFFICULTIES IN CARRYING OUT OPEN-INQUIRY

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This research deals with cases of science high school students and their teachers, who have done open-inquiry projects in order to participate in KYPT (Korean Young Physicists' Tournament, a national competition for international one, IYPT). The purpose of this study is to search for the effective instruction methods of open-inquiry by comparing students' and teachers' recognition about difficulties and helpful instruction methods during the activities. This research has been conducted through the participant observation while doing open-inquiry projects. After finishing the projects, the students were asked to answer a questionnaire about the activities, difficulties and their opinions in doing inquiry. Individual and group interviews were carried out as well. The research findings are as follows. The students state that planning and doing experiments were most difficult whereas the teachers view that students felt difficulties in interpreting the data and making a conclusion. With respect to the helpful instruction, students argue that they have got many ideas from the peer discussion although they had to carry out individual projects. On the contrary, the teachers think that references materials and discussion with themselves were most helpful to the students. It is concluded that it can be helpful to make up the team and to spend more time for peer discussion especially in doing experiments. Not only students' opportunities to learn background theory related to their inquiry, but also teachers' instructions based upon their experience are more required to complement insufficient peer discussion.

2. O2-A2

EXPLORING STUDENT METACOGNITION AND SCIENCE, TECHNOLOGY, SOCIETY, AND ENVIRONMENT ISSUES IN A THAI CONTEXT

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Gregory P. Thomas
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Metacognition is a thinking process necessary for promoting scientifically literate persons. The development and enhancement of students' metacognition is strongly emphasized worldwide, including in Thailand. This study aims (1) explored the metacognitive orientation of the classrooms of 1,376 Grades 10-12 students in Northeast Thailand and their perceptions of those environments. The Metacognitive Orientation Learning Environment Scale – Science (MOLES-S) analysis of the data revealed that the participants' classroom learning environments were not adequately metacognitively oriented. The participants' school, grade, gender, and age did not significantly influence differences regarding their perceptions. (2) explored the students' metacognition of 219 students in Khon Kaen Province with the Questionnaire of Metacognition on Science, Technology, Society, and Environment issues (QM on STSE), and interviews were employed for data collection. The analysis of the interview data suggested that more than 90% of the participants could not describe about how do they think and how they know about how they learn science. Contextual and cultural factors potentially influenced the participants' metacognition. Implications regarding students' metacognition and contextually and culturally-based teaching and learning about metacognition are also discussed.

3. O2-A3

EXPLORING SECONDARY SCHOOL STUDENTS' VIEWS OF THE NATURE OF SCIENCE IN MAINLAND CHINA

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Enshan Liu
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Presently, the importance of increasing students' understanding of the nature of science has been emphasized in recent science education reforms and national standards documents in many countries, including China. There has been much research on students' views of the NOS, but most of the studies focus on Western students. As for the non-Western students, and specifically Chinese students' NOS views, little research can be found. This research has three research questions, which are: (1) How Chinese secondary school students understand the nature of science? (2) Is gender disparity a factor which is related to students' conception of the nature of science? (3) Is students' interest in learning science correlate with students' NOS achievement? The data were obtained by using a Likert-Scale, multiple choice questions and interviews. Both quantitative and qualitative methodologies were adopted in this research. Paper-and-pencil questionnaires were administered to 465 middle school students. Eleven students were selected for participation in in-depth interviews based on their achievements of NOS views. This research shows that Chinese students' understandings of the nature of science are limited. In general, smaller gender differences are be found in the conceptions of the Nature of Science. As for some items, however, there exists a significant difference between boys and girls. The result also shows that students' achievement in the Nature of Science Questionnaire is correlated with their interests in learning science. Based on above research results, the teaching suggestions are also discussed.

4. O2-A4

ANALYSIS OF TYPES OF QUESTIONS EMBEDDED IN SCIENCE LESSONS OF JAPAN AND THE UNITED STATES

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University of Miyazaki, Japan

The purpose of this study was to analyze teachers' questions in science lessons of Japan and the United States, and compare their stereotypical types of questioning. Further, how frequent higher order thinking skills are favored over simple recall were also revealed in this study. Since the classical times until today, asking questions serves as a window of learning. However, it is very difficult to conduct research on science teachers' questions in a valid and reliable way. In this study, the national sample of science lessons in Japan and the US, taken from the TIMSS 1999 Video Study, were used in the analysis. 496 questions in English transcripts from four Japanese science lessons and 683 questions from four US lessons were analyzed using the Window Model originally developed in this study. The Window Model consists of types of questions (one pane attached to each sash), combination questions (grilles), and auxiliary questions (frame). Combination questions are represented by grilles, which support at least two panes together. Auxiliary questions can be likened to the frame attached to a sash assembly, which maintain the stability of an entire window. Window blinds diversify the window model into four variations, which take into account how much of a certain type of question is implemented in each part of a lesson cycle. According to the sets of lesson plans, similarities included the following (1) teachers from both countries asked factual questions to elicit prior knowledge and; (2) they also employed more factual questions than conceptual ones to explain concepts. Slight differences were noted on the following situations: (1) even though teachers from Japan and the US used factual and convergent combination types of questions during empower stage and exploratory stage, the former country used more convergent questions and; (2) factual-combination questions were asked to Japanese students during exploratory activities. Different questioning techniques also existed in some parts of the lesson cycle of each country: (1) conceptual questions were frequently used to engage Japanese students' attention while US students often answered factual questions during this part and; (2) Japanese teachers elaborated prior knowledge and newly assimilated ideas by asking factual and conceptual questions, but US teachers used factual questions to review the concepts learned in the activity. One original part was observed in Japan's science lesson cycle, wherein factual questions were frequently asked to Japanese students to extend students' engagement prior to the next lesson. Supplemental questions asked throughout the course of the lessons comprised 49.7% and 51.5% of the total questions embedded in Japanese and US science lessons, respectively. The findings of this study can be used for future identification and comparison of trends in effective questioning techniques in science classrooms.

- **Oral Presentation 2-B**
- **Date: Thursday, October 27, 2011**
- **Time: 10:20 ~ 11:40**
- **Room: #2 (1F)**
- **Chair: Shiho Miyake (Kobe College, Japan)**

5. O2-B1

A CASE STUDY OF PUBLIC SCIENCE COMMUNICATION IN THE JAPANESE MUSEUM SYMPOSIUM

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1. Research Framework: In recent years, informal science education in science museums and centres has been studied in the framework of science communication (Stocklemayer *et al*., 2001). For example, various studies have been undertaken of exhibition designs and museum visitors (Tulley & Lucas, 1991; Falk, 2001; Medved & Oatley, 2010). According to Gilbert (2001), it is important that science museums and centres provide follow-up activities to promote public science communication. In other words, along with the improvement of exhibitions, science museums and centres must carry out other activities to promote popular science communication.
2. Research Purpose: What is a follow-up activity to promote popular science communication? The Museum of Nature and Human Activities (MNHA) of Hyogo, Japan, began to hold a public symposium in 2006. At this symposium, citizens report on their activities. This project may be used as an example of a follow-up activity in the promotion of science communication. However no research has been clarified in what ways the symposium delivers the public science communication. This study will outline the characteristics of the MNHA's symposium, which is an original model of a follow-up activity in popular science communication.
3. Data Collection and Research Procedure: Periodical observations of the MNHA symposium from 2006 to 2011 were performed. In addition to these six years of observation, documentary resources of the symposium were collected. On the basis of these data, the study will outline and analyse (1) the categories of the participants and (2) the presentation topics and subjects.
4. Results and Conclusion: According to the categories of participants, 'local citizen' participants increased significantly in 2011, indicating that the museum symposium sought local citizens to present projects. In 2006, most participants were museum related learning groups, and in 2011, the number of schools and non-profit organizations grew slightly. In sum, the symposium participants have become more diversified over the course of six years.

The survey of the presentation topics and subjects reveals that the symposium covered broad contents, from local natural history to the ecological niches of living creatures. In 2011, the number of presentations on 'nature conservation', which includes habitat investigation and education, obviously increased. In conclusion, the symposium became an appealing place for local people and organizations to promote environmental conservation.

6. O2-B2

A STUDY ON THE SCIENCE-GIFTED CAMP AT EDUCATIONAL INSTITUTIONS FOR THE GIFTED

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In this study, using a questionnaire about camp programs, we surveyed 375 gifted education institutes, including 285 classes for the gifted, 70 institutes for the gifted at education offices, and 20 institutes for the gifted at universities. The survey questionnaire consists of questions relating to camp design, camp operation, and camp introspection. The questions relating to camp operation are subdivided into questions relating to content, process, product, and learning environment of the camp. In the analysis of camp design, experience-centered camps entailing visits to research institutes, science museums, and so on showed the highest ratio. The camps were generally carried out in summer vacation as two day/one night programs. The average score of camp content was 3.72, that of camp process was 3.78, that of camp product was 3.77, and that of camp environment was 3.58. In the analysis of camp introspection, the item 'a lack of information about diverse camp activities' showed the highest difficult thing. Integrating these results, we suggest that information about diverse camp activities should be developed and supplied and the camp environment strengthen the freedom of students to select camp activities.

7. O2-B3

A SCIENCE TEACHER'S BELIEFS AND PRACTICES OF TEACHING NANOSCIENCE IN AN INFORMAL SETTING

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National Cheng Kung University, Taiwan

Tai-Chu Huang
National Sun Yat-Sen University, Taiwan

Nanoscience is a branch of science and technology that is new and interdisciplinary, thus integrating it in curriculum presents many challenges to science teachers. This research aims to investigate how a middle-school teacher's beliefs and practices support student learning in an informal setting, a nanoscience camp. The corpus of data included video-recorded classroom observations and teacher interview. Three major findings emerged. First, in designing the curriculum, the teacher followed the sequence of understanding, experiencing, and applying. He indicated the importance of infusing examples that are relevant to the everyday lives of the students to spark their interests in the subject. Hands-on activities were designed for students to experience the properties of nanoscale materials and different applications of nanoscience were raised to expand students' understanding. Second, a "learner-centered" instruction was observed in accordance with the teacher's belief that the curriculum development should consider students' prior knowledge and interests. Third, the teacher used the practices of simplifying, guiding, practicing, and inspiring in teaching nanoscience concepts. In particular, simple analogies were used to facilitate student understanding. The results gathered from an informal setting provided implications for formal curriculum development, teacher education, and professional development in integrating nanoscience into science classrooms.

8. O2-B4

A STUDY ON DEVELOPMENT AND APPLICATION OF A SECONDARY SCIENCE TEACHING MODEL UTILIZING THE FARADAY'S IDEA DEVELOPING PROCESS

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In this study, we investigated how Faraday induced the concept of magnetic field line from the shape of iron powder spread over the magnet and then abducted the concept of electric field line. Then we developed a science teaching model and applied it to science classes of secondary schools utilizing Faraday's idea developing process. According to the test for the concept of magnetic field, we found that not only the middle school students but the high school students didn't understand well about the concept of magnetic field inside the magnets and found it more difficult when the magnets' shapes or arrangements have been changed. When we applied the Faraday's idea developing procedure to classes, We could help to improve the ability of understanding the magnetism such as the magnetic field lines inside the magnets as closed curves and applied problems(e.g. curved electric field lines).

- Oral Presentation 2-C
- Date: Thursday, October 27, 2011
- Time: 10:20 ~ 11:40
- Room: #3 (1F)
- Chair: J. Steve Oliver (University of Georgia, USA)

9. O2-C1

THE DESIGN OF KNOWLEDGE TRANSFORMATION SYSTEM (KTS)

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The interdisciplinary nature of complex systems and phenomena in science, technology, mathematics, and engineering (STEM) and the rapid development of the 21st century knowledge mandate that students need to organize knowledge efficiently and effectively both within and across disciplines (Bransford, Brown, & Cocking, 2000;

Rhoten & Parker, 2004). Unfortunately, extensive research has suggested that many students only develop isolated understanding when learning STEM topics – they have very limited strategies to meaningfully connect related concepts (Linn *et al*., 2006). A deep understanding of a science topic often requires multi-modal representation (Kozma & Russell, 2005). Educational research has documented learning strategies that focus on different knowledge representation modalities including writing explanations, viewing computer models, drawing concept maps, and more importantly, on linking these distinctive representations. In this paper, we describe an innovative web-based knowledge transformation system (KTS) to help students better organize, integrate, and transform scientific knowledge. The basic components of the system include three distinctive, editable modes: Event, Wiki, and Concept Map.

• The Event mode may include static pictures or dynamic computer models of physical events (e.g., nuclear power generation). In this mode, students encounter a holistic representation of a natural event and, with study, may develop an intuitive understanding of how different parts are interrelated to form a complex system (e.g., how nuclear reaction produce energy that pushes a mechanical turbine to generate electricity).

• In the Wiki mode, students write entries about specific terms that they encounter (e.g., what is nuclear energy?). This is similar to the popular Wikipedia that anyone can edit. Awareness of interconnections will arise from the editing process where student authors confront different constructions of knowledge as composed by others.

• The Concept Map mode will incorporate functions that students can use to produce concept maps (Novak & Canas, 2006). In this mode, students visualize the connections among a set of related science concepts based on their exploration of meaning at different levels of knowledge taxonomies (Anderson & Krathwohl, 2001).

A distinctive feature of this system is that these three modes are not independent of each other: We build a database structure that can link elements among these modes (e.g., students see a Concept Map in the view mode can be directed to a specific Wiki page or an Event page). The applications of the KTS system in science education will be discussed.

10. 02-C2

GENERATION GREEN PROJECT IN THAILAND: STUDENTS' SHORT FILMS TO PROMOTE THE AWARENESS AND ACTION FOR CLIMATE CHANGE ISSUES

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Generation Green Project (or Gen Green) is the project launched by Science Institute, Ministry of Education in Thailand that engages students and teachers from all over the country to participate in the production of media to stimulate the awareness of climate change issues. This is a 2 years long project for the leader groups which can communicate scientifically. The participants were 4 students and 2 teachers from 200 schools distribute by geographic educational districts. There were total 1,200 Gen Green members that intensively trained in 4 days workshop on both scientific concepts and media production such as exhibitions, graphics, drawings and short films. They also engaged in the Youth Summit for sharing their ideas on Climate Change. In the second years of the project, a group of participants produced a short film to stimulate the awareness of climate change issues and also inspired society to take action of the issues. They also become the leaders of Gen Green society which extends the group of people who use media for enhancing society to sustain the environment and reduce the natural resource depletion. The result from first phase indicated that students and teachers had high enthusiasm. They perceived that Gen Green is the symbol of new generation who communicate scientifically to public. For the workshop, students and teachers needed more training about short film production, for example, script developments and techniques of Storytelling.

11. 02-C3

EEG BRAIN ACTIVITY IN ENCODING PHYSICS-RELATED CONCEPTS

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Learning physics can be difficult because it involves understanding concepts that can be abstract at times. Recent research into brain activities can shed some light as to how the brain processes these difficult concepts in different modalities (i.e. words versus pictures). Previous EEG research into memory and learning has found that activations in different brain areas are related to encoding of information in different kinds of presentations. In our study, we presented sixty-six subjects with a Sternberg task, in which they judged whether a probe item was one of the four items on the encoding list. The lists consisted of three sorts of physics-related items, which we termed as pictures, high imaginable words (words in which students can easily conjure up an image), and low imaginable words (more abstract concepts). We used an ICA (independent component analysis) method to determine the EEG correlates related to the task. In particular, we examined the differences in the theta and alpha powers in the parietal and frontal area clusters. We found significant differences in alpha and theta waves in the frontal and parietal areas. The frontal areas are associated with attention and working memory. In general, for the frontal and anterior cingulate cortex areas, there was greater theta activation during the presentation of the word conditions. This could be interpreted as a need for sustained attention for non-picture related tasks and need for increase in cognitive load in terms of remembering and processing the non-picture items. Initial examination also showed a greater asymmetrical activation of the left frontal area for words, which supports previous research on the asymmetry of visual and verbal encoding. Previous studies on the role of the parietal area in working memory has produced mixed results. Research has shown that the left parietal is involved in semantic processing, whereas the right parietal's role is more unknown. Some studies showed no reliable activation of the right parietal, whereas some have implicated the area as pertaining to visuospatial processing of information. In our initial examination, we found that the low imaginable words activated the right parietal cortex. This could be that even though the low imaginable words are hard for people to draw or imagine, these physics words, such as force and inertia, can still elicit some visuospatial content. On the other hand, the parietal brain activations in the high imaginable word condition are more similar to the picture condition. This study provides a new way of investigating students' encoding of information in different presentations and gives new insight into how students can learn difficult concepts.

- Oral Presentation 2-D
- Date: Thursday, October 27, 2011
- Time: 10:20 ~ 11:40
- Room: #4 (2F)
- Chair: Hunkoog Jho (Seoul National University, Korea)

12. 02-D1

THE PATTERN OF RISK ASSESSMENT AND ITS ROLE IN UNDERGRADUATES' DECISION-MAKING ACROSS SOCIO-SCIENTIFIC ISSUES

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This study aims to elucidate what strategy of risk undergraduate students take use of to make decision across the issues and how their risk assessment affects their participation in discussion. Twenty-seven first-year undergraduates in an introductory science class were asked to debate the four socio-scientific issues as listed: the reliability of automobile recall, the effect of hybrid and fuel-cell vehicle to protect the environment, the authenticity of global warming and the safety of vaccination against swine influenza. As a way of discussion, snowballing strategy was implemented to encourage them to participate in discussion. The activity paper and homework submitted by the participants as well as the transcripts of group and classroom discussions were collected and analyzed. The result shows there are mainly four risk strategies used in decision-making: no loss, minimal loss, convenience and certainty. It is interesting to note that the students take use of the same strategy across the issues. In terms of the discussion, there are six key roles of initiator, critic, provider, coordinator, dreamer and follower found in the participants' debates. There is a tendency that some roles are in charge of specific risk strategy. Initiators and coordinators are up to moderate decision-makers of minimal loss strategy whereas critics and providers take no loss strategy. Dreamers and followers have varied strategies. It is conjectured that the risk perception is associated with decision-making and specific roles in debate and that the role exchange can facilitate students to have fruitful thinking for informed decision-making.

13. 02-D2

AN INVESTIGATION ON THE RELATIONSHIPS BETWEEN THE KNOWLEDGE, ATTITUDES, AND BEHAVIOUR DIMENSIONS OF ENVIRONMENTAL LITERACY AMONG URBAN AND RURAL FORM 4 STUDENTS IN SABAH, MALAYSIA

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Over the past 20 years, researchers have explored the status, delivery, and effects of Environmental Education (EE) using various types of national surveys. These surveys have primarily related to curriculum needs in K-12 programs in public schools. In several national surveys, researchers have assessed the level of environmental knowledge or attitudes of students in primary and secondary schools (e.g., Barraza & Walford, 2002; Makki, Abd-El-Khalick, & Boujaoude, 2003; Tuncer, Ertepinar, Tekkaya, & Sungur, 2005). Reviewers of research and evaluation studies have pointed out the limitations of surveys that narrowly focus on environmental knowledge or specific dimensions of environmental affect (e.g., Hines, Hungerford, & Tomera, 1987; Hungerford & Volk, 1998). In response, researchers have developed broader models of environmental literacy. Relatively, few efforts thus far have been made to assess students over this wider range of environmental literacy components (e.g., Chu *et al.,* 2007; Kuhlemeier, van der Bergh, & Lagerweij, 1999). The purpose of this study is to evaluate urban and rural Form 4 students' environmental literacy which includes the dimensions of environmental knowledge, attitudes, and behaviors. The ultimate goal of this study is to investigate the probable relationships between these different dimensions of environmental literacy, and their association with students' demographic variables such as gender and school location. This study will involve the administration of the Environmental Literacy Survey (ELS), a version of the Green's (1999) modified Wisconsin Environmental Survey. Descriptive statistics were used to gauge Form 4 students' environmental knowledge, environmental attitudes, and environmental behaviors. Independent samples t-test was used to determine if there is a significant difference in environmental literacy based on gender as well as school location. Pearson's product moment correlation analysis and multiple regression analysis were used to investigate the associations between environmental knowledge, environmental attitudes, and environmental behaviors among Form 4 students. This study offers a snapshot of environmental literacy among urban and rural Form 4 students especially in Sabah, Malaysia.

14. 02-D3

AFFECTIVE LEARNING OPPORTUNITIES IN PRIMARY SCIENCE LESSONS

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The first category of Affective Domain objectives in Bloom's Taxonomy is about "Receiving". In it, the first subdivision listed is "Awareness" (Krathwohl, Bloom & Masia, 1964). Since these categories are intended to be hierarchical in ascending order of internalization, it is important that young learners be given ample opportunities in their learning experiences in class to be aware of positive values and effective life skills. This paper presents pedagogical ideas to infuse affective learning activities into primary science lessons. Several concepts taught in the lower block (Primary 3 and 4) and upper block (Primary 5 and 6) science curriculum were identified for raising the awareness of values and life skills through an integration of cognitive-affective learning activities. The objectives of the activities are (1) to help learners understand or apply a taught science concept or skill, and (2) to use their newly acquired knowledge or skill as a prompt for them to reflect on some important positive values, attitudes or effective life skills. For example, a lesson on how a Plumb line is used in determining how vertical a tall structure (like a building or flag pole) is, may include an activity for students to reflect on why positive role models, like Thomas Edison or a caring close relative, are important in life. Eleven such activities have been crafted. The authors will share and demonstrate a sample of these activities that have been piloted with students from a primary school with aim of raising their awareness in positive values, attitudes and life skills.

15. O2-D4

ANALYSIS OF KOREAN HIGH SCHOOL STUDENTS' MORAL REASONING PATTERNS : USING ESSAYS ON THE NUCLEAR POWER GENERATION ISSUE

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This study analyzed Korean high school students' moral reasoning patterns represented in their essay writings on nuclear power generation issues. Especially, we investigated to what extent the students possessed character and values as global citizens. In order to achieve the aim, we adapted a theoretical framework for the 21st century scientific literacy (Choi *et al*., 2011). Character and values, suggested in the framework, included ecological worldview, socioscientific accountability, and social and moral compassion. We also analyzed student responses in the context of personal, societal, and global. Sixty five 10th grade students (18 males and 47 females) responded to the two essay questions over 50 minutes. The essay questions can be briefly summarized as follows: (1) Do you believe that Japan is responsible for the release of radioactive substances (in the case of the recent explosion of Daiichi reactors at Fukushima)?, and (2) Would you agree if the Korean government is planning to build more nuclear power plants in order to meet current demands of electric energy in Korea? In results, for the first question, the students presented socioscientific accountability at mostly societal level, and social and moral compassion at the personal level. And for the second question, they presented ecological worldview at the societal level, and socioscientific accountability at the personal and societal levels. The underlying evidences of their argument in the first question included, for instance, "the explosion was due to the earthquake and we need to remember Japanese heavily suffered from the damage currently" and "Japan is responsible because all other countries will be affected by radioactive substances soon. They should check in advance whether their plants are safe enough to endure big earthquakes." For the second question, the students referred various values prioritizing environment, safety, and economic profits. The results imply that the students seem to lack social and moral compassion and ecological worldview at the global level, and so science teachers need to help them to possess character and values as global citizens.

- Oral Presentation 2-E
- Date: Thursday, October 27, 2011
- Time: 10:20 ~ 11:40
- Room: #5 (2F)
- Chair: Chee Leong Wong (Nanyang Technological University, Singapore)

16. O2-E1

CAN DEFINITIONS CONTRIBUTE TO ALTERNATIVE CONCEPTIONS?

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There has been disagreement on the importance of definitions in science education. Yager (1983) believed that one crisis in science education was due to the considerable emphasis upon the learning of words, terminologies or definitions. Hobson (2004) disagrees with sixteen introductory physics textbooks which do not provide general definition on energy. Some textbooks explain that "there is no completely satisfactory definition of energy" or they can only "struggle to define it." In addition, Rossing (1995) explained that the lack of understanding of magnetic forces can be due to the confusion in terminology and definitions that exists in our physics courses and textbooks. In general, imprecise definitions in textbooks (Bauman, 1992) and inaccuracies in definition provided by teachers (Galili & Lehavi, 2006) may cause confusions or alternative conceptions. Besides, there are at least four challenges in defining physics concepts, namely the problems of circularity, precision, context and completeness in knowledge (Wong & Yap, 2010). These definitional problems which have been discussed or mentioned in The Feynman Lectures, may impede understanding of the nature of physics knowledge. In this study, qualitative meta-synthesis is employed to examine over hundreds of research papers, as well as some editorial comments and letters to the editor on definitions in physics, problems in defining physics concepts and how they may result in alternative conceptions. These research papers and articles are mainly selected from peer-reviewed journals such as *American Journal of Physics, International Journal of Science Education, Journal of Research in Science Teaching, Physics Education, Science & Education, The Physics Teachers*, and so on. There are also comparisons of definitions from research papers with selected definitions from textbooks, Dictionaries of Physics, and English Dictionaries. To understand the nature of alternative conception, Gyoungho Lee *et al*. (2010) have suggested a theoretical framework to describe the learning issues by synthesizing cognitive psychology and science education approaches. Taking it a step further, the current study incorporating the challenges in semantics and epistemology, proposes that there are at least four main variants of alternative conceptions which may arise from the four definitional problems in physics. The four variants of alternative con-

ceptions are namely:
1. Operational Conceptions (Based on operational definitions)
2. Imprecise (Vague) Conceptions
3. Mixed Conceptions (Mixing technical meaning with concepts from other contexts)
4. Incomplete Conceptions (Limited knowledge on concepts)

We may coin the term, "alternative definitions", to refer to the commonly available definitions which have at least four main problems in defining physics concepts, namely, circularity, precision, context and completeness. Based on this qualitative meta-syntheses study, alternative definitions may result in at least four variants of alternative conceptions. Note that these four definitional problems or challenges in definitions cannot be easily resolved. Educators should be cognizant of the four variants of alternative conceptions which can arise from alternative definitions. The concepts of alternative definitions can be useful and generalizable to science education and possibly beyond. The importance of definitions should deserve more attention from educators and students.

17. 02-E2

EFFECTS OF COOPERATIVE SMALL GROUP DISCUSSION ON ELEMENTARY SCHOOL STUDENTS' ARGUMENTATION AND ATTITUDES TOWARD SCIENCE IN TAIWAN

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This study investigated the effects of cooperative small group discussion on elementary school boys' and girls' argumentation and attitudes toward science. One hundred and eleven fifth grade students volunteered as an experimental group to join a 12-week cooperative small group discussion intervention; another 107 sixth grade students volunteered to be the comparison group. All participants completed the Student Science Learning Questionnaire (SSLQ) at the beginning and end of this study to measure their argumentation and attitudes toward science. In addition, 6 boys and 6 girls with the lowest total scores on SSLQ in the pretest were selected from the experimental group to be interviewed at the end of the intervention and for weekly observation. Exploratory factor analysis and internal consistency were used to examine the reliability and validity of instrument; t-tests, analysis of variances and analysis of covariance assessed the similarity and differences between genders and groups. The initial findings were as follows: experimental group students had significantly higher scores on attitudes toward science and argumentation than their comparison group counterparts; the experimental group boys gained significant progress on their quality of argumentation compared to the girls; the intervention effects were greater in boys with low self-expectation compared to the girls when evaluating their attitudes toward science and quality of argumentation. Qualitative results from interviews and observations were used for triangulation and consolidation of quantitative results. Implications and research recommendations are presented.

18. 02-E3

FROM SITUATIONAL INTEREST TO INDIVIDUAL INTEREST: THE IMPACT OF A CLASSROOM INTERVENTION ON COLLEGE STUDENTS' PERCEPTION OF LEARNING SCIENCE

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This quasi-experimental study explores how student cumulative situational interest (a short-term interest that is generated by specific situations) can be developed into individual interest (a relatively enduring phenomenon). A continuous intervention of integrating novelty and aesthetic experience (e.g., artful description of scientific conceptual knowledge combined with a deep appreciation for the beauty of science) into teaching was used for the experimental group (n=64) while another class of 105 students studying the same course of physical science without the intervention of novelty and aesthetics served as a comparison group. An external evaluation conducted by the office of academic affairs in the university revealed that student feedback from both groups was very positive. The analysis of covariance comparing the two group students' pre- and post-test perceptions of learning science revealed that the experimental group outperformed the comparison group in their interest, enjoyment, and aesthetic understanding. The weekly assessment of student situational interest indicated that the experimental group students' situational interests were well maintained by two leading learning activities: hands-on experiments and demonstrations with novelty and aesthetic experience. The above results provide empirical evidence to support the theory of interest development, which proposes that individual interest can be developed through sustained situational interest.

19. 02-E4

THE RELATIONSHIPS AMONG PRE-SERVICE CHEMISTRY TEACHERS' ATTITUDE-TOWARDS-CHEMISTRY, CHEMISTRY SELF-EFFICACY, AND CHEMISTRY LEARNING EXPERIENCES AT TERTIARY LEVEL

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The Theory of Planned Behaviour (TPB) is an all-encompassing theory that maintains behaviour is determined by many influences including significant individuals in ones life. According to the TPB, an individual's behaviour is influenced by their attitude toward that particular behaviour, their associates' (e.g., peers, family and mentors) attitude toward the behaviour, and the individual's perceived control over the behaviour. The purpose of this study is to investigate the association and the contribution of students' chemistry learning experiences on their attitude-towards-chemistry and chemistry self-efficacy at tertiary level. This is a non-experimental quantitative research and sample survey method will be used to collect data. Samples will be selected by

using a cluster random sampling technique. The Chemistry Attitudes Experiences Questionnaire (CAEQ) will be adopted to measure students' attitude-towards chemistry, chemistry self-efficacy and their chemistry learning experiences at tertiary level. The attitude-toward-chemistry consists of five subscales: attitude toward chemists, skills of chemists, attitude toward chemistry in society, leisure interest in chemistry, and career interest in chemistry. The self-efficacy scale consists of one scale with students not appearing to have different efficacious beliefs for the different tasks in chemistry. The learning experiences scale consists of four subscales: demonstrator learning experiences, laboratory class learning experiences, lecture learning experiences and tutorial learning experiences. Pearson product-moment correlation and multiple regression analysis will be used to test the stated null hypotheses at a predetermined significance level, alpha = .05. The research findings will bring some meaningful implications to those who are involved directly or indirectly in the planning and implementation of tertiary chemistry education.

- **Oral Presentation 2-F**
- **Date: Thursday, October 27, 2011**
- **Time: 10:20 ~ 11:40**
- **Room: #6 (2F)**
- **Chair: Jocelyn Partosa (Ateneo de Zamboanga University, The Philippines)**

20. O2-F1

METACOGNITION AS A TOOL IN ADVANCING READING COMPREHENSION IN A SCIENCE CLASS

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Reading comprehension is a critical learning outcome and cuts across all content areas. Using metacognition as a tool, this study aimed at advancing reading comprehension among biology majors. Specifically, the foci of the study were to recognize reading comprehension problems among biology majors; improve their reading strategies and reading comprehension and promote metacognition. Fourteen sophomore biology students in Plant Systematics were assigned 3 articles on separate occasions. A reading survey adopted from Joseph (2006) showed that the reading comprehension problems are generally of cognitive and affective origin, with all 14 students pointing to inadequate vocabulary as their most challenging. Reading behaviors like preference for a particular reading position and reading aloud were crucial to comprehension for some students, just as writing questions and appreciating pictures in the article were contributory to comprehension. Students' reading strategies mostly involved consulting the dictionary or the internet, rereading, note taking of important points or a combination of those strategies. Several students claimed that with metacognition they learned new ways on how to comprehend articles; even identifying factors that proved ineffective to comprehension were evident. Students also claimed to develop skills in monitoring their comprehension and correct misunderstandings. According to some students however, they need to improve in making inferences, synthesizing information and asking questions.

21. O2-F2

TO WHAT EXTENT ARE SOCIAL CONSTRUCTIVIST PERSPECTIVES IMPLEMENTED IN ASIAN PRIMARY SCIENCE EDUCATION? THE CASE OF VIETNAM

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The current primary science curriculum has been officially enacted in Vietnamese schools since the beginning of 2000s, after several years of being studied and piloted. It was claimed that the current science curriculum is composed appropriately with new pedagogy orientations in which students can be developed better in knowledge, skills, and attitudes towards science. Accordingly, many advanced and Western educational theories were affirmed to have been applied into the school science. Nevertheless, there are not many official studies regarding the application and implementation of social constructivist perspectives in Vietnamese primary school science though they have been studied, elaborated and applied in many science educations. This study was aimed at determining to what extent social constructivist perspectives, which are more Western-rooted, are implemented in primary school science in Vietnam, an Asian country that has been considerably influenced by Confucian culture. It was also addressed to investigate what could be fostering factors for the implementation of social constructivist perspectives in Vietnamese primary school science. Results uncovered that social constructivist perspectives are implemented to a low extent in Vietnamese primary school science. Besides, the distinct culture, student expectations, and student preferences were speculated as fostering factors for the implementation of social constructivist perspectives in Vietnam. The study suggested, therefore, that design research regarding the culturally appropriate application of social constructivist perspectives towards science education become necessary in Vietnam since it can contribute and enhance the quality of the primary school science.

22. O2-F3

USING CONCEPT MAPS AS A MEANS TO ALIGN JUNIOR AND SENIOR HIGH SCHOOL SCIENCE CURRICULA

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In most countries, junior and senior high school represent two distinct stages in terms of schooling. Moreover, the curricula for these two levels, regardless of which subject, are usually designed and penned by different expert committees. As a result, the two curricula may contain a wide spectrum of distinctions, from different level of difficulties to even dissimilarity in the way they appear in terms of structure. This happens to be the current situation in Taiwan, particularly with respect to the area of sciences. While the curriculum for the junior high school is organized in terms of integrated sciences and daily life technology, the senior high school curriculum is organized in the form of four science subjects, namely, physics, chemistry, biology, and earth science. A weak alignment between the two levels may affect some teachers in their instructional practices that may be attributable to their unawareness of students' knowledge status attained in the prior learning stage. This paper reports an attempt in Taiwan to bridge this gap. Two core concepts in physical sciences, namely, the composition of matters and the structure of matter, will be used as examples to illustrate how a common framework can be established by means of concept mapping. Since concept maps can visually reflect the hierarchical and logical relationships among the relevant science concepts, they can help junior high school teachers to grasp which concepts will later play an important role in the senior high school curriculum. In addition, they can facilitate senior high school teachers in identifying prerequisite concepts that have already been acquired by students in junior high school.

23. O2-F4

WHY DOES SCIENCE INQUIRY STUMBLE IN THE CLASSROOM? A META-ANALYSIS OF STUDIES DEALING WITH SCIENCE INQUIRY IN KOREA

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Inquiry-based instruction reflects cultural and educational environments of each country. Despite many studies on inquiry-based instruction, little attention has been paid on the impacts of educational systems and cultural setbacks. The purpose of this study is, through the meta-analysis of related literature, to investigate why the trials to implement science inquiry have not succeeded in the Korean socio-cultural context. We analyzed 61 articles that deal with science inquiry published in two representative Korean journals on science education: Journal of the Korean Association for Science Education (1971~2010) and Journal of Korean Elementary Science Education (1989~2010). The factors and phenomena related to inquiry-based lessons were identified through the analysis. The collected data were categorized according to six axes of grounded theory as follows : (a) causal condition- viewpoint of teachers, students, and instructional systems; (b) central phenomena- weak interplay between teacher and students, teacher-centered instructions; (c) contextual conditions- teachers' work environment, chance for teacher professional development, curricular and administrative support; (d) intervening conditions- score-driven educational system, content-focused assessment, excessive private lessons and inquiry-oriented curriculum; (e) actions/interactions- many efforts and studies to enhance doing inquiry in the classroom, conflicts between larger socio-cultural values and the goal of curriculum, instructions subordinate to content-focused assessment; (f) dichotomous consequences- inquiry-based instruction improvement and repetitive failure of inquiry. Through the analysis on the perspective of grounded theory, it is revealed that each factor and conditions are complicatedly connected with each other. And actions/interactions and consequences are dichotomous. As for positive strategies, many ways have been implemented to encourage interactions (e.g. collaborative activities, peer grouping, new questioning method, argumentation) and to enhance teaching practice (e.g. mentoring). The classroom materials and in-service training programs, which support the inquiry-based teaching, have been developed as well. On the other hand, in Korea's educational system, school assessments still focus on normative conceptual knowledge and private lessons are prevalent due to the over-emphasis on educational background. These conditions result in negative strategies such as teachers teaching normative conceptual knowledge to face socio-cultural demands of higher achievement and students studying for exams and high scores. In the context where science lessons still cling to conceptual understanding, which brings repetitive failure of inquiry. Consequently, because of a gap between the aim of inquiry-based instructions and the reality of education in Korea, both teachers and students are confused and inquiry-based instruction is of little influence in school science settings. Therefore, for science inquiry to succeed, it is necessary to pay attention to Korea's (or even to East Asia's) unique educational system and to the belief, values and experiences of both teachers and students within such a context.

- **Oral Presentation 3-A**
- **Date: Thursday, October 27, 2011**
- **Time: 13:20 ~ 14:20**
- **Room: #1 (1F)**
- **Chair: Bongwoo Lee (Dankook University, Korea)**

24. O3-A1

UNWEAVING RAINBOW: TEACHING SCIENCE USING RAINBOW

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The rainbow is an optical phenomenon that attracts human interests owing to its beauty and the difficulty in finding a scientific explanation. Many researchers were interested in a rainbow as an integrated context that could be used in an art, literature, music, religion as well as a science. The purpose of this study was to investigate theoretically the possibility of teaching science using a rainbow. This study had three parts. the first possibility was related to understanding the optics theory with a rainbow. We suggested the method to teach reflection and refraction though investigating the making process of rainbow, double rainbow and reflected rainbow. Also, we showed the method to teach an interference theory using the supernumerary rainbow. Second, a rainbow could be used as a material for scientific inquiry. The formation of rainbow was related with various conditions of ray and water drop. A various types of rainbow in the various condition(for example, variation of size and temperature of water drop, use of various liquid) can be the starting points for students' open inquiry. Finally, we explored the aesthetics of the rainbow for finding a new pedagogical approach to integrate the cognitive and affective aspect of scientific activities.

25. 03-A2

EFFECT OF NANOTECHNOLOGY INSTRUCTIONS ON SENIOR HIGH SCHOOL STUDENTS

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In this research, we cooperate with senior high school teachers in Taiwan, and design senior high school nanotechnology curriculum to understand the model of senior high school nanotechnology curriculum in Taiwan. Senior high school teachers teach 503 senior high school students nanotechnology curriculum, and use "Nanotechnology problem situation questionnaire" to measurement their learning. So, we not only know how students obtain these nanotechnology concept, but also can increase the number of nanotechnology talented person. The results showed: **1.** High school nanotechnology curriculum tends to explore the introduction and principle of technology product in daily life and high school teachers can use science curriculum base on their teaching, for example: Senior high school chemistry level 1 "Material in daily life" extend it to Ti-tech photocatalyst tile product we use, and inquire into it's titanium dioxide (TiO_2) material which will produce electron and electron hole after illuminated, then generates reactive hydroxyl radicals (OH-), peroxynitrite root Radical (HO_2-) and superoxide ion radicals (O_2-) when react with water and oxygen. These free radicals have the ability to decompose organic compounds. **2.** We obtain 453 valid nanotechnology problem situation questionnaires; questionnaire's recovery is 90.1%. After analysis, we found 20.31% of high school students (around 92 students) can answer the context they learn, but the concept about nano-science is incomplete; students can only tell simple nano-science principle, for example: TiO_2 illuminated reaction can generates free radicals and do sterilization. **3.** Collecting all kinds of students' answers, we can analyze their alternative conceptions to compile high school nanotechnology conception diagnostic test, which can do a comprehensive test and use it as designing nano-science curriculum reference documents, and help them to learn more information about nanotechnology.

26. 03-A3

INQUIRE LEARNING EFFECTS TO ELEMENTARY SCHOOL STUDENTS' NANOTECHNOLOGY INSTRUCTIONS

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Nanotechnology is an emerging science that involved in different fields. This research inquired elementary school students' learning effect by using quasi-experiment, expositive-teaching and experimental-teaching methods for nanotechnology in the microcosmic world. By utilized the pretest "Nanotechnology Situational Questionnaire (NSQ)", we have selected 110 fifth grade students with similar academic performance in nanotechnology knowledge from Northern Taiwan. The instruction designed 2 teaching steps. The first step had 4 class sessions, and then implemented the expositive-teaching to all the students. The main learning context was related to understand nanometer definitions, characters and fundamental concepts. The second step divided 110 students into treatment and comparison groups, each group had 3 class sessions. The treatment group implemented experimental-teaching, on the other hand, the comparison group implemented expositive-teaching by PowerPoint, animations and movies. After the experiment, the 2 groups completed posttest NSQ. The results showed: **1.** Two groups were no different in posttest NSQ score after the first step teaching, but after the second step teaching, the treatment group had significant higher scores than comparison group. It means that experimental-teaching method was more effective than the expositive-teaching. **2.** The experimental-teaching could simulate a realistic situation, and provided abilities in a clearer communication. Students were easier to understand and able to apply the science concepts into their daily life. For the intension of investing in future talents and promoting nanotechnology education, educators must adopt the nanotechnology into formal elementary curriculum and design a series of complete teaching plan.

- **Oral Presentation 3-B**
- **Date: Thursday, October 27, 2011**
- **Time: 13:20 ~ 14:20**
- **Room: #2 (1F)**
- **Chair: Kanchulee Punyain (OBEC, Thailand)**

27. 03-B1

SCIENCE PROJECT: AN INNOVATION FROM SCHOOL TO COMMUNITY (ENGLISH INTEGRATED SCIENCE APPROACH)

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An innovation developed by student's science project can be powerful vehicles for raising the understanding of science among the students and also useful in the winder communities. Therefore, the "Science Project: An Innovation from School to Community (SPISC)' was conducted by Science Education Center Srinakharinwirot University and Thatakopittayakhom School, Thailand as a partnership. The project focuses on improving teaching and learning in science classroom by using an innovation developed by the students as a science project and strengthen the connection between the classroom learning of science and technology and the broader application of science and technology in the community. SPISC project is conducted as an English Integrated Science Approach in three phases including program development, program implementation, and program evaluation. This research was a mixed method design. The example

group of this research were 50 middle school students who enrolled in science project class, Thatakopittayaknom school, Thailand. The tools of the research consisted of 6P lesson plan, science process skills test, attitude toward science test, scientific attitude test and a constructivist learning environment survey. The statistics used in data analysis were arithmetic mean, standard deviation and t-test. The result of this research found that after teaching, the mean score of science process skills, attitude toward science and a constructivist learning environment of middle school students being provided by 6 P instructional was higher than before at the .05 level of significance. No significant differences were found in scientific attitude at the .05 level of significance.

28. 03-B2

SoSTI COURSE : AN ELECTIVE SCIENCE COURSE FOR THAI UPPER SECONDARY SCHOOL NON-SCIENCE STUDENTS

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The purposes of this study were to develop the Science of Sound in Traditional Thai Musical Instruments course (SoSTI course), an interdisciplinary one, for Thai non-science upper secondary school students and to study the development of students' scientific creativity, the students' understanding in science of sound concept, the students' attitude toward science and students' awareness of precious Thai culture and tradition focusing on traditional Thai musical instruments before and after completing the course. The SoSTI course development was based on interdisciplinary concept model proposed by Jacobs (1989) and constructivist theory. The research study was divided into five phases, pre-developing the course, developing the course, conducting pilot study, implementation and evaluation and analyzing data and conclusion, respectively. The SoSTI course is an elective course corresponding to the Basic Education Core Curriculum B.E. 2551 (A.D. 2008). This course was conducted to thirty five non-science students in 12th grade in second semester of 2010 academic year at Rattanakosinsompoch Bangkhen School, Bangkok, Thailand for a whole semester. The research instruments were students' scientific creativity test, students' attitude toward science questionnaire, the science of sound understanding test, the students' awareness in traditional Thai musical instruments questionnaire, and students' opinions toward the SoSTI course questionnaire. The data were statistically analyzed by using t-test for dependent sample. The findings of this study indicated that, after complete the SoSTI course, the students' scientific creativity is significantly increased at the .05 level. The students' understanding in the science of sound content posttest score is significantly higher than the pretest one at .05 level. The students' attitudes toward science before and after completing the SoSTI course are not significantly different at the .05 level. However, students' attitudes toward science are significantly different at the .05 level by using item analysis. After studying from the SoSTI course, the students have become more aware of Thai culture and tradition focusing on traditional Thai musical instruments and they have positive opinion toward the course.

29. 03-B3

LET ME HEAR YOUR STORY: EXPLORING THE ROLE OF EVERYDAY EXPERIENCE OF PRIMARY STUDENTS TO PROMOTE SCIENCE DISCOURSE DURING PEER DISCUSSION

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Increasingly, more attention has been paid to the combination of a learner's knowledge and his or her everyday life. In the case of primary education, there have been many trials to enhance students' abilities to engage their knowledge with their experience. For example, subjects have been encouraged to participate in knowledge construction such as role playing, storytelling and collective works. It is assumed that they interpret the given information and reconstruct the knowledge based on what they have done before. The purpose of this study is to examine the role of students' past experiences in peer interactions during discussions of thermal concepts. The researchers observed a group of six fourth-graders in science discourse activities. The students were asked to scientifically illustrate a natural phenomenon. The researchers focused on their interaction patterns, which were videotaped and transcribed, regarding their conceptions. When students participated in the science discourse activity without talking about their past experiences, they tended to independently express an idea without reference to their peers' explanations, or accepted their peers' ideas without questions. They expressed their difficulty in understanding their peers' opinions and requested more detailed information or repeated explanations. However, when students conveyed their personal experiences in a story, the interaction was active; they exchanged their ideas through explanations, questioned their peers' explanations, or refuted them. As a result, the experience in everyday life plays a significant role during discourse. First, personal experience helps students focus on the discussion. During the discussion, most of the participants had difficulty in focusing on the activity (off-task). But after one student told her personal experience, the discourse group became more in the debate and talked about the related stories. Second, sharing personal experience facilitates students to invoke their memories. When talking about one's past experience, peers introduced their own stories related to the topic and participated in the discourse. Next, their experience was used for substantiating or refuting the argument. A student rejected another's claim by introducing his personal experience as counter-evidence or accepted it because his past experience was similar. Consequently, research indicates that there needs to be more concern about students' experience related to their daily lives in terms of conceptual development. Furthermore, activities where students share narratives relative to personal experience should be considered to promote student's participation in science discourse.

- Oral Presentation 3-C
- Date: Thursday, October 27, 2011
- Time: 13:20 ~ 14:20
- Room: #3 (1F)
- Chair: Gyoungho Lee (Seoul National University, Korea)

30. 03-C1

EXPLORING THE ORIGIN OF A SCIENCE TEACHER'S DILEMMA: A CASE OF TEACHING NEWTON'S FIRST LAW

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Recent studies have reported that understanding how to identify and to address science teachers' dilemmas in teaching science could enhance science teachers' expertise and improve their instruction. In this study, we explore a dilemma episode of a physics teacher who is confronted by student disbelief in Newton's First Law of Motion; there is the tension between students' personal experience and the formal representation of scientific knowledge. Especially, we tried to answer the question 'where the dilemma comes from?' from a philosophical perspective. In the result, we propose how each component of the dilemma is strongly related with a philosophical view; extreme objectivism and extreme relativism, respectively. And then we discuss how both of the extreme restrict our views on a very narrow part such as personal experience or formal representation of scientific knowledge and create a dilemma.

31. 03-C2

PRESERVICE SCIENCE TEACHERS' AWARENESS OF KNOWLEDGE AND SKILLS FOR INQUIRY TEACHING DURING THEIR TEACHING PRACTICES IN SCHOOLS

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The study examined preservice science teachers' awareness of knowledge and skills for inquiry teaching during their teaching practices in schools. Participants consists of 4 preservice science teachers who enrolled practices their teaching in Khon Kaen University (KKU) Demonstration School (modindaeng), second semester of year 2009. Methodology regarded interpretive paradigm. Tools of interpretation included questionnaire, interview, and participant observation. The KKU teaching practices course provided preservice teachers to practice their teaching for 2 semesters of the fifth year. These 4 preservice teachers have already passed the first semester of teaching practices from other schools. The findings clarified what and how they learn and aware of knowledge and skills for improving their teaching at the end of the second semester of teaching practices focusing on inquiry teaching. The paper discussed their perception about problems and solution of their teaching, pathway of gaining knowledge and skills for inquiry teaching, and aware of the lesson of 4 years before teaching practices and teaching experiences as knowledge base for improving inquiry teaching.

- Oral Presentation 3-D
- Date: Thursday, October 27, 2011
- Time: 13:20 ~ 14:20
- Room: #4 (2F)
- Chair: Lilia Halim (UKM, Malaysia)

32. 03-D1

STUDENTS' PERCEPTION CONCERNING SCIENCE TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE

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Pedagogical content knowledge (PCK) is a type of teacher knowledge to be developed by a teacher and PCK is said to contribute to effective teaching. Most studies investigated the development of PCK and its influence on students' learning from the teachers' perspectives. Lack of studies has looked from the students' perspectives of what components of science teachers' PCK that helped their learning. Thus it is the aim of this study to investigate the level of science teachers' pedagogical content knowledge from students' perspective, in particular whether students of different ability had different view of teachers' PCK in assisting their learning and understanding. Based on the PCK literature, six components of PCK has been identified, which were: (i) subject matter knowledge, (ii) knowledge of teaching strategies, (iii) knowledge of concept representational, (iv) knowledge of teaching context, (v) knowledge of students' understanding, and (vi) knowledge of students' assessment. Fifty-six Likert scale items were used for data collection from 316 Form 4 students (16 years old). One way ANOVA analysis revealed that there was statistical significance found at $p=0.004$ of science teachers' PCK for students of different achievement. Overall, students of various academic achievements view all the components of PCK as important. However, the low ability students view less important on all the components of PCK compared to the high and moderate achievers. In particular, low ability students do not view 'Knowledge of Concept Representational' as important for effective teaching. On the other hand, they value the fact that teachers should be alert to their needs, such as sensitive to students' reaction and preparing additional learning materials. This study reveals that the current PCK of science teachers from the perspectives of the students has not being able to meet the various needs of the students.

33. 03-D2

METACOGNITION THAT PUPILS REALIZE THEIR CHANGES IN THOUGHT

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This presentation discusses how to encourage pupils to verbalize their feelings and thoughts in the science classroom, and introduces the science lesson to which one of the authors has applied this method in a primary school in Japan. The encouragement is based on anti-essentialism or relationism: the doctrine that relations have a real existence. Because relationism gives priority to relations over essence that causes a thing to be a particular kind, relationism is opposed to essentialism: the doctrine that essence has a real existence. On the basis of essentialism, the task of science and philosophy is accepted as discovering essence beyond phenomena and expressing it in their definitions. Obviously, natural science has been based on essentialism. but, it is not justifiable that science education should be based on essentialism. From the disciplinary point of view, science education should belong to social sciences and humanities, where relationism has gradually become a main stream of investigation, namely structuralism, constructivism and constructionism. It is more appropriate for science teachers to accept anti-essentialism because science teachers work not at investigating natural phenomena but at educating pupils. However, many science educators are inclined to consider pupils on the basis of essentialism. An advantage in science educators' having the relationist outlook is the outlook naturally lead them to relativize natural science to pupils' indigenous knowledge system which they are excepted to assimilate in their language-culture community. without having the relationist outlook, science educators would accept exclusive status of natural science inevitably. As an example of science lesson based on relationism, this presentation demonstrates how a relationism outlook encourages pupils to verbalize their feelings and thoughts in the sixth grade science lesson. The content of the grade six science lesson to which one of the authors applied the present procedure was: When plant-derived substances are burnt, oxygen in the air is used and carbon dioxide is generated. First, the teacher started the lesson by showing a burning phenomenon. Next, the teacher encouraged each pupil to verbalize his or her feelings and thoughts against the backdrop of other pupils. At the same time, each pupil accepted suggestions for verbalizing his or her feelings and thoughts about the phenomenon from the teacher in a relationship between the pupil and the teacher. Then, each pupil was led to verbalize his or her feelings and thoughts about the phenomenon in another relationship between the pupil's selves. This process is shown in the video record of the lesson. As shown in the video record, each pupil has a worksheet on which several blank balloons are drawn during the whole of the experiment. The balloons are in a column wise order. Each pupil writes down every thought in the balloons in order. As the result, pupils have their sequential thought in the experiment respectively. The worksheet helps each pupil to objectify his or her thought. This leads the pupils to realize the relationship between the pupil's selves. At the same time, realizing that another pupil stimulates a verbalized thought, the pupil understands the relationship between the pupil and his or her classmate. this is the first step of the pupil's procedure of meta cognition: an ability to control his or her own learning. Furthermore, the teacher can make clear understanding of pupils' thoughts.

34. 03-D3

DEVELOPMENT OF INQUIRY-BASED TEACHING PROGRAM VIA PCK AND UBD: A PROFESSIONAL DEVELOPMENT FOR BIOLOGY PRESERVICE TEACHER

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This research aims to explore the effects of an Inquiry-Based Teaching (IBT) professional development program on preservice teachers' knowledge, attitudes, and skills concerning inquiry-based teaching. Three major stages were involved in this study; 1) Identifying Pedagogical Content Knowledge in an Undergraduate Inquiry Biology Lab Course, 2) Designing an IBT program and, 3) Evaluating the use of IBT program. The results from stage 1 led to eight PCK components for inquiry-based teaching which were presented in Spider diagram. These derived PCK were then used to develop a program and implemented with 11 preservice teachers. Learning strategies used in the program consisted of immersion experiences in 45-hour workshop and microteaching practice. The collected data in this study included 1) pre and post-lesson plans to track the knowledge changes, 2) observation of pre and post-microteaching inquiry behaviors, 3) pre and post attitude toward inquiry-based teaching and 4) satisfaction toward IBT program. Other qualitative data were also collected as follows: field note, video tape recording, journal and informal interview note.

The data indicated that prior to participating in the IBT program, preservice teachers had limited knowledge in designing inquiry-based instruction. It also showed that their intended learning outcomes were greatly emphasized on content learning rather than process learning. Lesson plans of the preservice teachers presented unclear cognitive structure of the task. The nature of students' involvement was low and the teaching was lack of variety of instructional materials. Teaching styles were didactic. The preservice teachers' behavior and students' behavior in relation to inquiry were seldom presented during pre-microteaching.

The results from the post-program data showed that there were changes in the following components: 1) Intended learning outcome, 2) cognitive structure of the task, 3) level and nature of student involvement, 4) Way of giving feedback, and 5) Familiarity with equipments. The results from attitude questionnaire showed that construction and manipulation of inquiry-based equipment was the only subcomponent that statistically showed significantly difference ($t = 1.125$, $p < 0.05$). The satisfaction score towards IBT were the highest of all item considerations. However, the data also indicated that in some cases, the inquiry-based teaching knowledge and behaviors after the microteaching remain unchanged. These data showed the obstacle and limitation factors that limit preservice learning. The findings in this study provided the suggestions for preservice learning regarding to the essential knowledge and skills needed for facilitating inquiry-based instruction and also presented the possible factors that constrain the implications of inquiry-based teaching.

- Oral Presentation 3-E
- Date: Thursday, October 27, 2011
- Time: 13:20 ~ 14:20
- Room: #5 (2F)
- Chair: Yu-Ling Lu (National Taipei University of Education, Taiwan)

35. O3-E1

A PRELIMINARY STUDY ON THE EFFECTIVENESS OF INTEGRATING THE CREATIVE THINKING TEACHING APPROACH WITH EDUCATIONAL GAME LEARNING FOR IMPROVING TRADITIONAL SCIENCE TEACHING

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Creativity has been regarded as the core of science enterprise. It is also believed to be a crucial factor for supporting economy and culture development in any society. In light of its importance, many countries have declared to develop their creativity education in many aspects. However, due to severe restrictions, such as, the lack of literacy that teachers need for creativity education, the impossibility to manage innumerable thinking at the same time during the class, etc., not much has been significantly changed in conventional classroom settings, in terms of developing students' creativity. To explore an alternative solution, this preliminary study developed an innovation approach, namely, Integrating the Creative Thinking Teaching with Educational Game Learning (ICT&EG) Approach. This approach (as well as the educational game) was designed by researchers of this study and for 5th to 7th graders to play and learn. The theme of learning was "WaterLook", which was a role-playing-game. In this game, student was situated in a problem solving context. A four-stage design characterized this instructional approach: aware, planning, executing and evaluation. For the purpose of knowing the comparative effectiveness of this innovative instructional teaching approach and the conventional teaching approach, a quasi-experimental research design was adopted. Two 6th grade classes participated in this study. One class was assigned as the experimental group, which was taught with ICT&EG Approach; the other class was assigned as the conventional group, which was taught in a traditional way. Both groups experienced 12 class sessions (40 minutes/per session) of learning, spread equally in 3 weeks. The Creativity Test: Creativity Assessment Packet (Williams, 1980) was used for pre- and post-tests. The data collected were then analyzed with ANCOVA statistics.

Results: Experiences gained from the implementation showed that using ICT&EG Approach in school was feasible. The statistics also showed that students in the experimental group learned significantly better than those in the conventional group. This comparative effectiveness demonstrated that the ICT&EG Approach was potential in creativity education in science class.

36. O3-E2

ENHANCING THE CREATIVE PROBLEM SOLVING SKILL BY USING THE CPS LEARNING MODEL FOR SEVENTH GRADE STUDENTS WITH DIFFERENT PRIOR KNOWLEDGE LEVELS

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This study aimed to enhance creative problem solving skill by using the Creative Problem Solving (CPS) learning model which was developed based on creative problem solving approach and five essential features of inquiry. The key strategy of the CPS learning model is using real life problem situations to provide students opportunities to practice creative problem solving skill through 5 learning steps: engaging, problem exploring, solutions creating, plan executing, and concepts examining. The science content used for examining the CPS learning model was "matter and properties of matter" that consists of 3 learning units: Matter, Solution, and Acid-Base Solution. The process to assess the effectiveness of the learning model used the experimental design of the Pretest-Posttest Control-Group Design. Seventh grade-students in the experimental group learned by the CPS learning model. At the same time, students at the same grade level in the control group learned by conventional learning model. The learning models and students' prior knowledge levels were served as the independent variables. The creative problem solving skill was classified in to 4 aspects in: fluency, flexibility, originality, and reasoning. The results indicated that in all aspects, the students' mean scores of creative problem solving between students in experimental group and control group were significantly different at the .05 level. Also, the progression of students' creative problem solving skills was found highly progressed at the later instructional periods. When comparing the creative problem solving scores between groups of students with different levels of prior knowledge, the differences of their creative problem solving scores were founded at .05 level. The findings of this study confirmed that the CPS learning model is effective in enhancing the students' creative problem solving skill.

37. O3-E3

AN ANALYSIS OF PATTERN OF CREATIVE SCIENTIST'S PROBLEM FINDING AND HYPOTHESIS AND PROGRAM DEVELOPMENT FOR IMPROVING SECONDARY SCHOOL STUDENTS' CREATIVITY THROUGH ITS APPLICATION: EINSTEIN'S CASE

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This papers aims to analyse the pattern of Einstein's creative thinking and develop the program for secondary school or introductory university level. We mainly focused on the three outstanding Einstein's

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paper ; "Light quanta(1905)", "Special relativity(1905)", and "General relativity(1917)." In the theory of Light quanta, his quantum postulate emerges from an analogy between radiation and an ideal gas. The phenomenon of magneto-electric induction impelled Einstein to postulate the principle of special relativity. In General relativity, he postulate the equivalence between a uniform gravitational field and oppositely directed constant acceleration, the equivalence principle. Based on the three literature review, we devised several types of exemplary creativity programs like essay, story reading and module. These program were pilot-tested by middle, high school and university student. We analysed their response and achievement in qualitative and quantitative manner. Finally, we would propose the most ideal model of creativity program for the pedagogical means.

- Oral Presentation 3-F
- Date: Thursday, October 27, 2011
- Time: 13:20 ~ 14:20
- Room: #6 (2F)
- Chair: Huann-shyang Lin (National Sun Yat-sen University, Taiwan)

38. 03-F1

THE INTERPLAY OF TEACHERS' CONCEPTIONS OF INQUIRY, THEIR CURRICULUM PLANS AND TEACHING PRACTICES

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The purpose of this study is to investigate teachers' conceptions of inquiry, their curriculum plans and teaching practices for developing students' inquiry abilities in a professional development program. The professional development program consisted of a 3-time inquiry learning workshop, a 4-time inquiry curriculum plan workshop, and a visit to the classroom. Participants in this study were four experienced elementary science teachers. Classroom observation, semi-structured interviews, nature of science instruments, and feedback sheets for curriculum plan were data sources. Three teachers participating in the professional development workshops gained a better understanding of how to design inquiry curriculum for fostering students' inquiry abilities than the other one without participation. The results revealed that teachers' reflections on their practices, and their teaching conceptions (e.g. conceptions of inquiry, educational purpose, and students) influenced their weights of inquiry abilities in curriculum plan. Teachers' satisfaction of current teaching model became the barrier of teaching change. The findings suggest that teachers' reflection on past experience of lab or inquiry teaching should be emphasized in professional development program to reevaluate the weights of inquiry abilities and make change of their teaching practices.

39. 03-F2

IMPROVING COLLEGE STUDENTS UNDERSTANDING OF TIME-VARYING VELOCITY DURING ELASTIC COLLISION USING MICROCOMPUTER-BASED LABORATORY

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Understanding of the time-varying velocity that acts between two objects in the collision is the ability to apply them successfully in learning and interpreting linear momentum-impulse theory of introductory physics. However, incorrect breaking graphs and zigzag graphs during the collision were presented on students' worksheets. These students maybe have a system of beliefs and intuitions about physical phenomena to interpret what they use in the physics course. Widely reported the Microcomputer-Based Laboratory (MBL) can gather data with no bias in laboratory work and graphs from the acquired data can display instantaneously. In the collision experiment, 44 college students were randomly organized into an MBL Group and a Photogate Group. And, a physics elastic collision test is designed to ask the students to graph time-varying velocities before, during and after each carts collision and write down the reasons of making the graphs accordingly. The results of the study revealed experiment through MBL appeared to be a useful vehicle for understanding time-varying velocity during carts collision. It may be appropriate to use MBL in the physics experiments in order to improve students' physics comprehension of introductory physics.

40. 03-F3

THE IMPACT OF ARGUMENT-BASED GENERAL CHEMISTRY LABORATORY INVESTIGATIONS USING THE SCIENCE WRITING HEURISTIC (SWH) APPROACH ON COLLEGE STUDENTS' USE AND EMBEDDING OF MULTIMODAL REPRESENTATIONS IN SUMMARY WRITING

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This study aimed to examine the effects of argument-based chemistry laboratory investigations using the Science Writing Heuristic (SWH) approach on students' use and embedding of multimodal representations in summary writing. Participants of this study were thirty nine freshman students majoring in science education at a National University in Korea. Argument-based chemistry laboratory investigations using SWH approach was implemented for twenty three students enrolled in one cohort and the traditional chemistry laboratory teaching was implemented for sixteen students enrolled in the other cohort. Summary writing samples were collected from students before and after the implementation. Summary writing samples produced by students were examined using an analysis framework for examining the use and embeddedness of multimodal representations. Summary

writing was categorized into one of verbal mode, symbolic mode, and visual mode. With regard to the embedding of multi- modal representations, summary writing samples were analyzed in terms of ‘constructing understanding,’ ‘integrating multiple modes,’ ‘providing valid claims and evidence,’ and ‘representing multiple modes. Data analysis shows that the students of the SWH group were better at utilizing and embedding multimodal representations in summary writing as they provided evidence supporting their claims. This study provides important implications on pre-service science teacher education.

- Oral Presentation 4-A
- Date: Thursday, October 27, 2011
- Time: 17:00 ~ 18:40
- Room: #1 (1F)
- Chair: Jui-lin Chen (National Taipei University of Education, Taiwan)

41. O4-A1

THE HABITAT CREATION ON CAMPUS TO IMPROVE ELEMENTARY SCHOOL STUDENTS' ECOLOGICAL LEARNING OF INSECTS

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In this more than one hundred years old sustainable school in Taiwan, Shenkeng Elementary School has a habitat on campus built with biodiversity and eco-technology, even more curiously, the science teacher found that most of the students neither like the habitat on campus nor interested in insects. The science teacher took the insect habitat on campus as the learning situated fields to scaffold the fourth graders (n=27) to construct the relevant concepts about Insect ecological learning, methods used in this study are mainly qualitative. Integrated the flow learning idea suggested by Cornell, a role-playing and performance strategy in this study, the students could go deep into the habitat on campus and observed insects to recognize the external features of insect and to know insects’ living environment by playing games and finishing the working sheets in teaching activities. This study provides a clear understanding that (1) there was a big change of students’ attitude toward the insects and the insect habitat on campus .After the situated learning strategy, students appreciated the habitat on campus and understood the value of habitat, (2) most children changed their worldviews of habitat on campus from a human-centered perspective to an eco-centered perspective, also understood and could explain the meaning of biodiversity and eco-technology, (3) the results showed the impact of situated learning on students’ conceptual change, and after the activities most children were interested in insects, and they could take action to protect the habitat of insects for proper environmental action, (4) the result could be a reference for instructional designers’ courses designing.

42. O4-A2

ANALYSIS AND DEVELOPMENT OF EXPERT CONCEPTION IN JUNIOR HIGH SCHOOL NANOTECHNOLOGY CURRICULUM IN TAIWAN

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Chia-Chi Sung
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In order to understand the effectiveness development of junior high school nanotechnology curriculum and analysis knowledge of nanotechnology conception in Taiwan, researchers formed a team by invite union of junior high school nanotechnology teaching teachers, nanotechnology expert, and science education expert for making joint efforts in expert conception of junior high school nanotechnology curriculum development in Taiwan. As conclusion: 1.Completely transform the expert concept map of junior high school “nanotechnology” into declarative knowledge statement, including: the definition of “nanotechnology”, natural phenomenon, skills development , products, and affective attitude. 2. Junior high school nanotechnology statement transform expert concepts map into declarative knowledge statements, emphasizing the meaning between scientific terms and increasing the number of science principles description. 3. Transfer expert concept map and declarative knowledge statement into junior high school nanotechnology opened-questionnaire which divided into 18“proposition situation”. We ask student to read the “proposition situation”, and then answer one to three open-ended questions.

43. O4-A3

EXPLORING MODEL CO-CONSTRUCTION AND GROUP NORMS BY THE PATTERNS OF SOCIAL INTERACTION

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The social interaction in small groups is a valuable tool to facilitate students to co-construct knowledge. However, many research reported on the difficulties in social interaction in the classroom. This study aims to identify the influence of a unique group atmosphere on peer interaction and model construction in small groups. We categorized the patterns of social interaction according to the zone of interaction and the task engagement, and identified group norms and model established in each group. Ten groups of 4 students in 8th grade participated in an analogy based inquiry for blood flow in the heart. Students’ behaviors and dialogues during group activities were videotaped and recorded. The results show four patterns of social interaction: on task/collective zone, on task/multiple zone, on task/individual zone, on+off task/multiple zone. Group norms allowed us to identify membership, etiquette, and justification. Positive membership and etiquette created a friendly atmosphere for group interaction and reasoning. On the other hand, negative or nonresponsive membership and etiquette not only deterred collaboration and interaction between peers, but also impeded task fulfillment and model co-con-

struction in groups. Especially, there was very little justification for their claims even in groups that showed the on task/collective zone.

44. 04-A4

THE EFFECT OF THE OPEN INQUIRY LEARNING ACTIVITY

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The purpose of this study is to investigate the effects of the open inquiry learning activity over tradition instruction on 7 grade students' achievement and multiple intelligence. The subjects of this study consisted of 120 7 grade students from four classes instruction . One of the classes was randomly assigned as the experimental group , which was instructed with open inquiry learning and the other class was assigned as the control group, which was instructed with traditional instruction. Achievement Test and multiple intelligence Test was administered to the experimental and control groups as a post test. Analyzing the data by comparing and studying the relation between Achievement and multiple intelligence score to the experimental and control groups. The result show that the achievement and multiple intelligence of experimental group made a significantly higher mean score than those in the control group at the .05 level of significance and

45. 04-A5

THE EFFECT OF THE READING FRAMEWORK IN IMPLEMENTATION OF THE SCIENCE WRITING HEURISTIC (SWH) APPROACH IN SECONDARY SCIENCE CLASSROOM

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This study aimed to examine the effects of the reading framework in implementation of argument-based inquiry using the Science Writing Heuristic (SWH) approach on students' science summary writing, critical thinking, and reflection. Participants of this study were 8th grade students in the middle school in Korea. Three classes were selected among five classes at the school and the SWH approach was implemented for two classes of them and the traditional laboratory teaching was implemented for one class. One of the SWH classes (R-SWH) used the reading framework attached the SWH writing template. Results of this study indicated that there was significant difference in both students' science writing and the critical thinking abilities. Students in R-SWH group showed better performance on the level of reflection in the SWH writing template. This study provides important implications on students' science learning.

- **Oral Presentation 4-B**
- **Date: Thursday, October 27, 2011**
- **Time: 17:00 ~ 18:40**
- **Room: #2 (1F)**
- **Chair: Hong-Wen Cheng (National Taipei University of Education, Taiwan)**

46. 04-B1

USING A 3-D ACTUAL MODEL - THE "SUN ALTAZIMUTH" - TO SUPPORT STUDENT UNDERSTANDING OF CONCEPTS OF THE SUN-EARTH RELATIONS

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This quasi-experiment investigated the effect of the presentation of a newly developed instrument一 "Sun Altazimuth", which can easily represent the solar motion observed at any time, in any date, and at any location on Earth, in comparison with the traditionally adopted teaching material of sundials. Pretest and post-test data for 160 fifth grade students of primary school in Taipei County were used to address the research question and the relationships between the performance of students and their spatial abilities. Students, independent of their spatial abilities, showed significant improvement in knowledge of the apparent solar motion. This suggests that the students are cable of learning the accurate description of apparent celestial motion through the manipulation of "Sun Altazimuth." The results also demonstrate the value of both kinesthetic learning techniques and the way how a 3-D actual model of solar motion supported students to develop conceptual understandings of various astronomical phenomena that required a change in the frame of reference.

47. 04-B2

EXTRACTING STATEMENTS DESCRIBING THE NATURE OF SCIENTIFIC OBSERVATION (SDNSO) AND TEACHING IT TO HIGH SCHOOL STUDENTS

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Scientific observation is a starting point for the acquisition of knowledge and the scientific inquiry. Even though scientific observation looks simple, it is complex activity in nature. Therefore we need to study the nature of observation more in detail. In this study, we described various characteristics of scientific observation based on literature review of scientist's, science educator's and philosopher's views about the nature of scientific observation. As a result, we extracted 17 SDNSO (Statements Describing the Nature of Scientific Observation). these 17 statements can be categorized according to the process of following scientific observation; 1) Sensation as sparkling point for scientific observation, 2) Perception through attention (selection, organ-

ization, interpretation), 3) Recognition/Identification as conceptualized cognition, and 4) Description for communication. Next, We developed 18 worksheets to help students understand the nature of scientific observation. And it was applied to 46 high school students in 10th and 11th grades. As a result, it was found that students' understanding about the SDNSO was significantly increased 0.67 points in 5 stages of Likert Scale (p<.001). Among 17 SDNSOs, it was found that students' understanding about 16 SDNSOs was increased. Even though it was found that students' understanding about only one SDNSO (Context-laden observation) was decreased, it was not statistically significant. And among above 16 SDNSOs, increases of students' understanding about the 10 SDNSOs were statistically significant (Interactive observation, Observation by comparison, Observation above sensitive experience, Selective observation, Organized observation, Presupposed observation, Instrument theory-laden observation, Uncertain observation, Insufficient observations as a starting point and the basis, Fallible observation). And the increase range of these 10 SDNSOs was 0.28~1.83 in 5 stages of Likert Scale from -2 to +2.

48. 04-B3

USING KWL AND CUD TO ENHANCE AND ASSESS STUDENTS' LEARNING AND ENCOURAGE STUDENTS' QUESTIONING ON FORCE AND MOTION IN GRADE 10

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A Classroom research aimed at (1) eliciting students' prior knowledge, (2) encourage students' questions before and after the lesson, and (3) assess students' learning. The students were offered a teaching strategy namely KWL (what you Know, what you Want to know, and what you have Learned) by using "KW" in lesson opening stage to elicit students' prior knowledge and students' interesting on the topic (what they wonder/want to know) and using "L" in closing the lesson. In lesson opening stage, teacher can detect students' misconception and encourage students' questioning. After proving learning activities (focusing on hands-on/mind-on) on force and motion (projectile motion, simple harmonic motion and circular motion) in grade 10 , the students were asked to review their conceptual understanding by using a teaching strategy namely CUD (Conceptual Understanding Domino). CUD is a turn and talk technique start with randomly select a student (using name card). The first student talks only one idea about a given concept. After that the teacher select another student to continue talking about another idea that associate to previous one, and so on. The CUD is finished when the students' conceptual understanding on the given concept is completed. If the student's idea is correct he/she gets one star on the card. Results of the study are as the following: (1) students have some misconception on force and motion (detected from prior knowledge) such as : a projectile has zero velocity at the beginning, a projectile has no acceleration, acceleration of a projectile depends on the apply force when throwing an object, a circular motion has a force a long the curve, a circular motion has equal centripetal and centrifugal force, the period of a pendulum depends on its mass. (2) Students are able to ask some productive questions such as why, how to, what if ···, if··· then. The CUD help students review their conceptual understanding and assess their learning to full fill KWL. The CUD shows that students improve the learning, thinking skill, and be able to correct their misconception through the learning activities and peer discussion. They also enjoy playing while assessing their learning with CUD.

49. 04-B4

THE IMPACTS OF WRITING IN ARGUMENT-BASED INQUIRY ON SCIENCE LEARNING

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This study aimed to examine the effects of science writing as a learning tool according to the writing format. One hundred seventy-four, 7th grade students were grouped into three: argument-based inquiry writing group, informal writing group, and traditional report writing group. Students in argument-based inquiry writing groups used a structured writing involved argumentation, claim, and evidence. Students generated and record their own problem in a problem context given and developed and record procedure of their experiment through communications each other and recorded data and develop their own claim based on data analysis. Traditional report writing also requested students to write data and conclusion using a structured writing, but students did not have to design an experiment. They did simply their experiment following directions given by teacher or textbook and were not engaged in argumentation. Students in informal writing group write a story related to the topic of experiments that they engaged in. This study provides important implications on effective science writing format as a science learning tool.

50. 04-B5

INVESTIGATION AND IMPROVEMENT OF STUDENTS' READING COMPREHENSION PERFORMANCES IN SCIENCE PICTURES

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The purpose of this research was to investigate students' reading comprehension ability and their improvements regarding science pictures. There are two phases in this study and four 5th graders (n =4, 2 high and 2 low achievers) were invited to participate. In the first phase, some science pictures in the curriculum were chosen as the instrument to test students' reading abilities and the qualitative data were collected by open-ended questionnaires and interviews. The results indicated that competent readers can easily identify the meanings in the picture compared to their counterparts. Additionally, they can paraphrase the keywords in pictures and would not be interfered by their reading comprehensions like the poor readers did. Although both group of students liked linking specific words or elements in the pictures to assist in their comprehension, the competent ones were more efficient and organized. Furthermore, all students intentionally or mindlessly ignored some details in the pictures, and tried to interpret the pictures with their familiar conceptions. In the second phase, the participants were assigned with reading comprehension instruction (RCI) which was designed according to the findings in the first phase. The RCI adopted in this study includes noticing the details, making the connections, and finding the relationships in science pictures. The experimental results revealed that students with RCI performed better reading comprehension in science pictures than before. They could notice much more components and details in the pictures, and can make the connections to understand the relationships. Finally, the interviews showed that the low achievers benefited more from RCI than the high achievers, which means that the RCI can facilitate students' reading comprehension abilities in science pictures. Implications for teaching reading comprehension in science pictures and future researches were discussed.

- Oral Presentation 4-C
- Date: Thursday, October 27, 2011
- Time: 17:00 ~ 18:40
- Room: #3 (1F)
- Chair: Angie Y. C. Chen (National Science and Technology Museum, Taiwan)

51. 04-C1

PROMOTING PRE-DOCENTS' UNDERSTANDINGS AND PRACTICES IN THE CONTEXT OF INFORMAL SETTING

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For the most science learning at science center, it is critical for docents (explainers at science center) to be equipped with appropriate knowledge and practices which guides students to be exposed to the authentic environment where students are exposed to experience scientific literacy. 20 pre-docents at college level participated in this study and interacted with students at elementary and middle school levels at science camp offered by science center. The researchers designed science camp programs which are expected to promote students' scientific literacy, scientific knowledge, inquiry skills (experimentation for practicing procedural skills and argumentation for practicing scientific thinking skills), affective domain such as nature of science, and the relationship among STS (Science-Technology-Society), which were in turn embedded in the program with the following guide-questions. For example, one of activities was about 'making fire' by rubbing sticks; Pre-docents guided students with the following activities; (1) Share the value of fire in our lives with the guide questions; "Why do we need fire in our lives?" (2) Check what we knew about 'fire'-Check the prior concept or misconcept with the following guide question: "Did you have any experience about making fire before?" (3) Plan what we want to know-we collect more data to know 'fire' better and more with the guide question; "What are the elements of combustion?" (4) Learn inquiry procedural skills-Teach students how to make fire and practices by themselves this experiment in groups, (5) Provide alternative contexts-where fires can be interpreted differently, which means 'positive' and 'negative' impact on our life in two ways, where we can expect two groups of students would debate good things and bad things-students can develop scientific thinking skills by doing this argumentation process, and finally (6) Share how they felt about this program-what was success or failure. Students participating in science camp had chances to learn scientific principle, practices inquiry skills, experience nature of science, and understand the relationship among S-T-S. The questionnaire and interview with camp observations were used to explore the change of pre-docent's understanding and practices about science of informal setting, science center. The professional pre-docents program and docent education system can be implied as one of ways to enhance the quality of informal science learning at science centers.

52. 04-C2

THE LEARNING EXPERIENCES OF PARTICIPANTS OF SCIENCE CAFES IN JAPAN

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Many efforts in remedying the issue, "decline of interest in science" among Japanese people, It is not only decline of children's level and motivation in learning science but also ordinary citizens' poor interest towards science and ignorance of advantages of science. While such social phenomena have been reported frequently, there are few studies on the specific characteristics of people who have interest in science so far. Science café, an event for citizens talking with scientists in order to be familiar with science, has started in 2005 in Japan. Since then, its styles and themes have become diverse. Although in Japan there have been various kinds of initiatives and means to increase numbers of people who are interested in science, there have been few efforts to uncover what kind of past learning experience is effective for citizens to expand their interest from their childhood to adult. The present study tries to reveal how past learning experiences of participants of science cafés in Japan affect their current interest in and attitudes toward science. The study consisted of two parts, questionnaires and interviews on participants of two of the science cafés held in Tokyo. We could obtain 50 questionnaire responses and 10 interviewees. The findings indicated most of the participants were interested in science in their childhood and their favorite subjects were not only science but also other subjects such as history. Also, they had some experiences relevant to science through media and books. However, they received those information unintentionally. Their major reasons for participating the science cafés were just to cultivate themselves or learn about contemporary social issues, and were not necessarily linked directly with science itself, because science and technology components were usually involved in most of the social issues. Other characteristic of the participants was their 'activism.' Participants are, in other words, very active in exploring or investigating what they are interested in. Besides attending to the science cafés, they also attended to public lectures and they often visited libraries and bookstores to get answers to their own questions. However, where this 'activism' comes from is still an open question. One of the implications from this study is that school teachers may need to support and encourage children (future citizen) to cultivate their own curiosity and to be active. Further implications will be also presented.

53. 04-C3

AN EXAMINATION OF THE NOTION OF SCAFFOLDING IN AN INFORMAL SCIENCE LEARNING CONTEXT

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Informal science learning which goal is popularization of science can rouse learners' interest in science and offer opportunities of fruitful interaction. It is also able to provide the direct and real inquiry experiences to learners. Therefore, it becomes an object of attention as a way to make up for the weak points of formal school science. Nevertheless, learners learn more effectively and really when they receive the scaffolding and the proper guide, rather than when they are in totally free-choice environment. However, the notion of 'scaffolding in the informal science context' is still not clear. For that reason, the authors try to find the appropriate and evolved notion of scaffolding in the informal science learning context and build their theoretical framework. In particular, a science museum is considered as a representative of the informal science context in this study. Through the previous literature review, the key elements of original notion of scaffolding are extracted, and the critical features of scaffolding in the informal science learning context and their significance are examined. From the result of this study, the authors expect to apply the theoretical framework to analyze the learning process and produce practical proposals to use appropriate scaffolding medium in the informal science learning context.

54. 04-C4

THE INFLUENCE OF TEACHING STRATEGIES TO THE LEARNING INTEREST OF JUNIOR HIGH STUDENTS IN INFORMAL NANOSCIENCE CAMP

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Interest plays an important role in learning. In comparison to the participating countries in TIMSS and PISA, students in Taiwan have demonstrated high level of scientific knowledge but low level of interest and confidence in science learning. This paper aims to investigate how to teaching strategies influence the learning interest of junior high students in informal nanoscience camp. We investigated 120 junior high students' interest and achievement by questionnaires and recorded the teacher's teaching strategies by video tape during nanoscience camp. We also interviewed teacher and selected students after nanoscience camp. The results showed that:
(1) Student's situational interests were enhanced more than individual interests in nanoscience camp. Maintained interest (sense) and triggered interest were enhanced the most. (2) Teacher adopted more diverse teaching strategies in camp than in school. Teaching strategies included hands-on, experiment, demonstration, movie, pictures, PPT, play, teaching aids, Q&A, discussion and writing worksheet in nanoscience camp. (3) Students selected hands-on activity, play and experiment for enhancing learning interest and; however Q&A, discussion and writing worksheet were less selected for improving interest in nanoscience camp. (4) Teacher's diverse teaching strategies and teacher-student interaction frequency may be correlated to enhance students' interest and achievement about nanoscience camp. We suggest that teacher adopted more diverse teaching strategies and teacher-student interaction in science curriculum may be important ways to promote junior high student's learning interest.

55. 04-C5

RELATIONSHIP BETWEEN THINKING STYLES AND SELF-REGULATED LEARNING ABILITY AND SCIENTIFIC INQUIRY ABILITY OF KOREAN SCIENCE GIFTED STUDENTS

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This study examined the thinking styles of Korean Science-gifted Students on the basis of Sternberg's theory of mental self-government, and the relationship between thinking styles and self-regulated learning ability of science-gifted students and their science inquiry ability by the different types of thinking styles. Sternberg's(1988, 1990, 1997) theory of mental self-government addresses intellectual styles as an interface between intelligence and personality. The basic assumption is that the way individuals use their mind is analogous to various dimensions of government in the external world. Just as there are many ways of governing our society, there are many ways of governing or managing our daily activities. These different ways of governing or managing our activities are what Sternberg(1988, 1990, 1994) calls 'thinking styles'. This theory postulated 13 thinking styles that fall along 5 dimensions. These are functions(including the legislative, executive, and judicial thinking styles), forms(including the hierarchical, oligarchic, monarchic, and anarchic thinking styles), levels(including the global and local thinking styles), scopes(including the internal and external thinking styles) and leanings(including the liberal and conservative thinking styles) of the mental self-government. Participants were 110 students who 14~16 age from the education centers for the gifted in science affiliated to university in Korea. Participants responded to the Thinking Styles Inventory(Sternberg & Wagner, 1992), Self-regulated Learning Inventory(Seo *et al*., 2004), and Science Inquiry Inventory. Results indicated that Korean science-gifted students showed very high self-regulated learning ability than general students

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in previous study(Jung *et al*., 2004). In cognition level, general cognitive strategies of elaboration and organization ability were ranked high in Korean science-gifted students, and those students who showed highest levels of self-regulated learning ability displayed various personality thinking styles. Results also showed that Korean science-gifted students prefer the legislative, judicial, anarchic, global, external, and liberal styles. Science-gifted students' science inquiry ability was more significantly correlated with the thinking styles than those of self-regulated ability. Results from the stepwise multiple regression analysis procedures indicated that the subscales of thinking styles could be significant predictors of scientific giftedness. Implications of these findings for both teaching and research for gifted students are discussed.

- **Oral Presentation 4-D**
- **Date: Thursday, October 27, 2011**
- **Time: 17:00 ~ 18:40**
- **Room: #4 (2F)**
- **Chair: Hye-Eun Chu (Nanyang Technological University, Singapore)**

56. 04-D1

STUDENTS' UNDERSTANDING IN DIFFERENT CONTEXTS OF FUNDAMENTAL OPTICS IN SINGAPORE AND KOREA

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In recent years, the importance of the context in which science is learned has received greater attention by researchers and curriculum developers. Consequently, the purpose of the study was to demonstrate how students' understanding of optics concepts in different contexts may be conveniently evaluated using two-tier multiple-choice items in two different countries and to provide evidence for the nature of context-based learning and its assessment. A large scale quantitative study involving 1,233 Korean students and 1,149 Singapore students from Years 7 to 9 was undertaken to evaluate their understanding of fundamental optics concepts. The Light Propagation Diagnostic Instrument (LPDI) consisted of two concept groups in two different contexts, using four pairs of two-tier multiple-choice items. Research findings showed that 1) four general alternative conceptions about light propagation were held by 10%-30% of the students in both Singapore and Korea across all school years. Most alternative conceptions of light propagation were not context-dependent. 2) Except for gender, each of the variables, country, school and school grade, had an influence on students' basic optics conceptions. However, the strength of variables was weak except "school" (Eta2=0.29)" in Singapore while it had no impact in Korea. "School grade" also affected students' conceptual understanding in Singapore but the strength of variable was weak (Eta2= 0.02). However, "School grade" did not affect Korean students' optics conceptions. The findings show that there was weak conceptual progression across the school grades in fundamental optics concepts. In this paper we seek to elucidate and explain the reasons for the stability of and inter-relationships between students' conceptions about light propagation and visibility of objects in different contexts across three years of secondary schooling in Singapore and Korea.

57. 04-D2

A NEW MODEL FOR MATH AFFECT

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This paper explored the math affects of students. The respondents for this research were asked whether they love or hate mathematics. They were also asked for the reasons behind their answers. The paper used thematic qualitative data analysis to process the data. The result of the study showed that math affect is not purely bipolar, that is, it is not simply love or hate. The researcher found there were categories in between. In the analyses of the reasons behind the students' affect towards math, it was found that there were three main reasons why students love math and four main reasons for hating it. The researcher also found that a good model to explain math affect is a two dimensional model. The paper will discuss the two factors involved in this two dimensional model, and the five math affects resulting from the interaction of these two factors. The result of this study will be important in understanding math affects and how it affects learning of Physics which is generally believed to be influenced by the student's attitude towards math.

58. 04-D3

PRIMARY SCHOOL STUDENTS' SCIENTIFIC LITERACY AND READING ABILITY: THE STUDY IN THAILAND

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Scientific literacy and reading ability are recognized as important tools for learning science. To understand primary school students' scientific literacy and reading ability would help the teachers and the education organization develop learning experiences to improve both scientific literacy and reading. These abilities are important for preparing students to learn science at higher levels. In this study, sixth grade students' (n = 175) scientific literacy and reading ability were explored with the scientific literacy and reading ability test (SRT). The SRT includes 30 questions with the reliability of 0.742. The three components of science competencies are the ability to explain phenomena scientifically (EPS), identify scientific issues (ISI), and use scientific evidence (USE) and two components of reading performances are the ability to retrieve and interpret information. The results showed that the mean score of the SRT was 16.02 with a standard deviation of 4.793. The students' mean score, in reading ability, was significantly higher than sci-

entific literacy. There was a positive significant relationship between reading ability and scientific literacy. The girls' mean score were significantly higher than the boys.'

59. O4-D4

ANALYZING THE SPECIAL SCIENCE ELEMENTARY SCHOOL PROJECT FOR GIFTED CHILDREN IN THE PHILIPPINES

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In response to the growing importance of science and gifted children in the Philippines, the Special Science Elementary School Project (SSES Project) was first implemented in 2007. This project is intended for gifted children in public elementary schools with a goal of producing scientifically literate students that will pursue study in special science high schools. Hence, the purpose of this presentation is to analyze the SSES Project. Specifically, it seeks to answer the following questions: (1) what is the process in identifying children for the project?; (2) what type of science curriculum is offered for the children?; and (3) what are the qualifications required to become an SSES teacher? A comparison between the SSES Project and regular schools are also explored in this presentation. The study used documents, articles, and department of education memo and orders as main sources of the analysis. The results of the analysis showed that SSES Project, although it is also a part of public school, was different from regular public school in terms of the following: selection process for students; qualifications of teachers and science curriculum. Children should pass stages of written, oral and psychological tests. For example, all incoming Grade 1 students, with permission from the parents, will be given written test (English, Math and Science), reading test and interview, 50 students who got the highest rank will move to the next level of screening process which is the psychological test. Students will be ranked based on the result of first phase (50%) and second phase (50%) and only those on the top 35 out of 50 were included in the project. Aside from the four subjects for Grades 1 and 2 in the regular curriculum, the project offered enhanced science curriculum in grades 1 and 2 which is formally stated in grade 3 in the regular curriculum. The enhanced science curriculum for this project is design to develop higher-order thinking skills through learner-oriented activities with an integration of ICT instruction. The subject is taught longer than the allotted time in regular curriculum: 60 minutes for grades 1 to 3 and 80 minutes for grades 4 and 6 to give more time and emphasis on science concept and process. Finally, both schools followed the qualification set by the law to become public school teacher, however, the project included additional qualifications in selecting teachers such as willingness to participate and support the project, performance, and specialization in science and/or relevant training in the subject. The implementation of the project may serve as a tool to strengthen the importance and awareness of providing appropriate science program for gifted children in elementary level. Further, the aim of producing scientifically literate gifted children that may pursue science related professions may be achieved through this project.

60. O4-D5

REDEFINING THE UNDERLYING STRUCTURE OF THE ROSE INSTRUMENT AND ITS APPLICATION TO UNDERSTAND CHINESE STUDENTS' AFFECTIVE DOMAIN OF SCIENCE LEARNING

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The questionnaire instrument of the international project called ROSE (Relevance Of Science Education), which investigates the affective domain of science learning for 15-year-old students, was administered to 70 classes of Chinese students in Hong Kong, Shanghai and Guangzhou of China and 2,426 valid questionnaires were returned together with 251 student interview records. The present work focused on the quantitative analysis in which our preliminary analysis indicated that the reliability for the Section D on "Me and the environmental challenges" was rather low (just around 0.7) as compared with 0.95 or above for all other sections and so its 18 items were discarded in our subsequent data analysis. After using the principal component analysis for data reduction, our EFA (exploratory factor analysis as based on the maximum likelihood estimate) revealed 25 key factors for 173 items taken from this ROSE questionnaire and they could be grouped into 4 categories by our expert's judgement, to wit, (A) 11 for what the students want to learn, (B) 7 for students' experiences on science and technology within or outside school, (C) 4 for students' science and technology related career orientation, and (D) 3 for students' opinions about science and technology. A second level EFA on those 25 factors led to 6 categories (or known as factors of factors) in which the previous categories A and B were each subdivided into another 2 highly correlated categories. However, using the AMOS software for second level confirmatory factor analysis, it was found that the EFA findings were actually consistent with our initial expert's judgment of having 4 main categories of factors. By using the factor loadings as weights for summation of items within each factor, our present work demonstrated that factor scores and their average values could easily be calculated for comparing the students' level of interest in various science topics and attitudes towards science vs gender, socioeconomic factors and banding of their schools across different cities. For our subsequent full-scale ROSE survey as conducted in Hong Kong and Shanghai, the data could be used to verify the present structural model of the ROSE instrument for the Chinese learners and to yield the category scores (i.e. second level factor scores) for the individual students so that they would know about their own level of affective domain of science learning as compared with the norm in their own school and own city. Furthermore, it will be discussed on how those factor and category scores can be treated as some reliable and concise indices for teachers to provide counseling on students' choice of further studies in the science stream or future career orientation in the field of science and technology.

- Oral Presentation 4-E
- Date: Thursday, October 27, 2011
- Time: 17:00 ~ 18:40
- Room: #5 (2F)
- Chair: Hyunju Lee (Ewha Womans University, Korea)

61. 04-E1

PRE-SERVICE SCIENCE TEACHERS' DECISION-MAKING TRAJECTORY ON SOCIOSCIENTIFIC ISSUES

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This study explored Korean pre-service science teachers' decision-making trajectory on socioscientific issues. The guiding research questions were as follows: (1) Do pre-service science teachers (PSTs) change their decision as going through group discussions with their peers? And (2) if they so, what are the main reasons for the change? If not, what are the main reasons that they persist with their initial stance even though they were exposed to opposite arguments? Eighteen PSTs who registered in a science education method course at a woman's university in Seoul participated in this study. Their specialties varied in physics, chemistry, biology, and earth science. We chose two SSI contexts including nuclear power plants vs. renewable energy, and embryonic stem cell research. The instructor presented each of the issues over a total of four weeks. Each was considered for approximately 5 hours (2 class periods over 2 weeks). Using the two SSI contexts, we designed a program emphasizing dialogical reasoning process among PSTs because previous research suggested that students' moral reasoning could be influenced by that of others and this reciprocal relationship could help them enhance the quality of their own arguments. PSTs were likely to experience dissonance among different ideas of their peers and to negotiate and resolve that dissonance. The primary data source was audio-taping of PSTs' small group discussions (each group discussion lasted about 30-40 minutes on average). Secondary data source included individual writings on their opinions after each class. In results, four types of decision-making trajectories (Type A–Type D) were found. PSTs in Type A persisted with their initial stance regardless of the group discussion. PSTs in Type B changed their positions after the discussion. While PSTs in Type C became clearer about their position and so finally took a stance on the issues, PSTs in Type D felt rather confused after the discussions and so could not make a decision at the end. Regarding the two SSI, the majority of PSTs were categorized into Type A (15 for the nuclear power plant issue and 11 for the embryonic stem cell research issue). The teachers admitted that they were somewhat faltering while listening to persuasive arguments of others, but tended to prioritize their personal values. For instance, they prioritized economical values/ ecological worldview or safety of human beings for the nuclear power generation issue, and gave more weight to their religious beliefs, intrinsic values of human beings, or therapeutic benefits for the embryonic stem cell research issue. Even though a majority of PSTs persisted with their initial position, this study showed that PSTs at least had opportunities to experience multiple perspectives and dissonance and to reflect their own values over the group discussions of the program.

62. 04-E2

HOW BELIEFS REGARDING THE NATURE OF SCIENCE INTERACT WITH WORLDVIEW PRESUPPOSITIONS HELD BY KOREAN IN-SERVICE SCIENCE TEACHERS AND BIOLOGISTS

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A recent concern in science education is that in spite of attempts to enhance science teachers' views on the Nature of Science (NOS) through various approaches by science teacher educators, their views are not consistent with the expected understanding of several aspects of the NOS as described by the National Science Education Standard. We believe it possible that teachers' views of the NOS may be related to their worldview presuppositions on Nature and Causality. In this study, Q-methodology was used to examine the relationship between teachers' beliefs regarding the NOS and presuppositions regarding Nature and Causality. Eighty-one statements were used from several instruments: Nature-statements, the Test of Preferred Explanations (TOPE), and the Nature of Science Scale (NOSS). Participants were 16 in-service science teachers and 5 university biologists. Biologists were purposely selected as professional scientists to explore possible differential interrelations in terms of their NOS beliefs and presuppositions compared to science teachers. The data was analyzed using centroid factor analysis with graphical and varimax rotations. As a result, eighteen participants were placed in five factors. Regarding the relationship within Nature, Causality, and the NOS, the study indicates a range of interrelations. Interestingly, four out of five biologists were placed in one group, and teachers were placed in other four factors.

63. 04-E3

EXPLORING SCIENTIFIC LITERACY OF UNDERGRADUATE ENGINEERING IN THAILAND CONTEXTS

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This research aimed to explore the situation of undergraduate's scientific literacy in Northeast of Thailand. Participants were 516 undergraduates engineering first year who take chemistry subject in year 2010. Research tool was developed from PISA (2006) as open – ended questionnaire that is Scientific Literacy Test (SLT). The finding showed that the students performed rather low level in the science literacy aspects. Such as: the scientific knowledge understanding and relationship between science social and technology have scored at 32.65%, the awareness to there are ethic and scientific attitude have scored at 29.6%, and the application science in daily life rationally have scored at 35.34%. This result suggested that the reformation of teaching and

learning in science classroom for undergraduates engineering students is necessary.

64. 04-E4

BEGINNING TEACHERS' STRUGGLING TOWARD THEIR PROFESSION OF SCIENTIFIC INQUIRY: THEORY INTO PRACTICE

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There had been studies reporting that beginning teachers experience conflict between theory and practice of their science teaching and it is very pivotal that beginning teachers keep reflecting on their theory and practice toward their profession. This study was to explore how beginning teacher struggle and survive to be professional in teaching science as inquiry. The questionnaire developed by the researcher was used to capture 47 beginning teachers' view about scientific inquiry first before induction program, whose name was 'authentic scientific inquiry into the classroom'. Out of 47 participants, 5 beginning teachers participated in reflecting on their theories and practices about scientific inquiry, during which the researcher offered two or three seminar related to scientific inquiry, where 5 participants developed new theories about authentic scientific inquiry. Then, the researcher observed their teaching practices in the classroom to see consistency between theories and practices (2-3 lessons per participants after each seminar) for two years. The results were as follows; (1) In the beginning of this study, the majority understandings about scientific inquiry was 'hands-on' perceived by participants. (2) In the middle of the study, the understandings about scientific inquiry seemed to be changing into 'minds-on, as well 'as 'hearts-on' beyond the 'hands-on' about scientific inquiry perceived by participants, supported by questionnaire 1 (checking general perception about scientific inquiry after seminars offered by the researcher) and another questionnaire 2 (guided inquiry teaching strategy of the content of plate tectonics). (3) However, it was shown that newly formed understandings about scientific inquiry was not explicitly embedded into their practices right away, supported by the last questionnaire 3 (open inquiry of content of air pressure), where participants selected more 'hands-on' teaching strategy rather than other two (minds-on and hearts-on) in teaching 'air-pressure' again even though participants seemed to have newly formed understandings. (4) Participants struggled to survive from the conflict between theory and practice through consulting process with the researcher, during which participants kept reflecting on their theories and practices of scientific inquiry to be professional. Participants tried to implement chances for students' experience the nature of science and argumentation, through which students could meet the goal of scientific literacy. For conclusion, beginning teachers must be given mandatory 'induction program' where they can reflect on their theories and practices to develop their professional career, since 'teachers' themselves nobody else can provide students with opportunities of experiencing authentic scientific inquiry beyond the 'hands-on' in the classroom. Induction program must be offered with the appropriate time and period so that beginning teachers could experience their conflict enough and have enough time to reflect on and change theories or practices if necessary.

65. 04-E5

A FRAMEWORK FOR LOCAL ECOTOURISM IN MARAGONDON, CAVITE, PHILIPPINES: IMPLICATIONS TO CURRICULUM DEVELOPMENT

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A successful ecotourism requires multidisciplinary approach. This study explores the integration of the views of the stakeholders in the community and in the academe, and in the local government agencies towards establishing a tourist destination in Maragondon, Cavite, Philippines. Survey and interview data were triangulated. Majority of the respondents believed that there is a huge prospect of becoming a tourist destination because of its rich history and biodiversity. They also believed that a tourist site will improve infrastructure, create job opportunities, and develop appreciation and conservation of their natural resources. Most of the respondents believed that the primary considerations in establishing the tourist site are safety of the people, preservation of the region's culture, and conservation of the environment. These findings suggest that for ecotourism to succeed, the framework of multi-disciplinary literacy should be developed among stakeholders in the local community, academic and government agencies. Curriculum developers in science education and other discipline should consider enhancing curriculum in this framework.

- Oral Presentation 4-F
- Date: Thursday, October 27, 2011
- Time: 17:00 ~ 18:40
- Room: #6 (2F)
- Chair: Hisashi Otsuji (Ibaraki University, Japan)

66. 04-F1

APPROACHING CULTURAL BACKGROUND IN SCIENCE INSTRUCTION: AN EXAMPLE OF JAPAN INFLUENCED BY MAHAYANA BUDDHISM

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This study is related to the new field of "Cultural Studies of Science Education (CSSE)." Although, in the school subject of history, culture is defined in terms of the aristocracy, the field of cultural studies of science education conceives culture as being created among the large majority of citizens, which the pioneer of Japanese folklore Kunio Yanagita (1875 - 1962) named "Joumin (常民)." Based on this folkloric cultural perspective, the view of social structure and spiritual structure, such as a sense of community or a system of motivation, emerged as an important issue along with the view of nature and indigenous science. A survey which focuses on "the view of nature", "indigenous science" and "education" revealed that the influence of (Mahayana) Buddhism is common to these concepts. In terms of practical aspect,

teachers at the attached elementary school of Tsukuba University (Yuan Tokyo Higher Normal University), which is a leader in science education in Japan, were found to hold Buddhist thoughts, as seen in the result of previous folklore survey. Surprisingly, they had been teaching science as a cultural phenomenon over the last 30 years. Thus, it is suggested that, in promoting cultural studies of science education in Japan, "social structure", "spiritual structure" the potential influence of Buddhism be considered.

67. 04-F2

THE STUDY OF KOREAN VIEW OF NATURE

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Taoism, Confucianism and Buddhism have influenced East Asian countries for a long time. The East Asian countries have their own unique natural environments, and their own views of nature have been developed within them. In this study, the Korean view of nature was discussed by analyzing literature, mythology, folk tales, and proverbs. Korea has a long history of science and technology. The goal of traditional science was harmony with nature. Nature is thought to be a parental presence for Koreans. They have adapted themselves to and compromised with nature. The notion of mountain gods, dragons and a heavenly god have emerged from the fact that Korea is Peninsular; surrounded by the sea on three sides with mostly mountainous regions supporting an agricultural society. Since there were no isolated areas and natural phenomenon changed rapidly, pantheistic and monotheistic ideas coexisted. As Koreans adapted with their natural environment they tried to achieve the oneness of heaven and man, man being the combination of heaven and earth. However, current school science education is carried out under the western view of nature. While Koreans' view of nature was formed in a long history, the history of science education is short. That causes difference between students' science knowledge and the actual natural understanding . Students' view of nature needs to be considered and reflect the socio-cultural structure in science education.

68. 04-F3

STUDENTS' VISUAL REPRESENTATION OF MATHEMATICS

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This paper takes another approach in assessing students' perception of mathematics. Instead of asking for verbal description of the students' perception of mathematics, the researcher asked the respondents to draw mathematics whatever they perceived it to be. This unusual approach forces the students to take a second look of how they perceive math. It also tap the students' creativity and gives a less austere appearance to mathematics which is taken usually in a more formal and severe manner. This approach of assessing students' perception of mathematics generates new information that cannot be normally gleaned from other approaches like Likert Scale. Some drawings of mathematics of the respondents reinforced their math affect towards mathematics. For those who hated math, their drawings revealed so – the same is true with those who loved mathematics. Examining the visual representations of mathematics gathered in this way and looking for commonalities, the researcher found a number of interesting themes that may shed some light to educators' understanding of students' math affect.

69. 04-F4

FIDELITY OF IMPLEMENTATION: BUILDING ON WHAT WE HAVE DONE IN SCIENCE EDUCATION RESEARCH

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School-based curriculum innovations, including those in science education, are usually not adequately evaluated, if at all. Adopting Fidelity of Implementation (FOI) criteria can determine and narrow the separation between programme intent and actual implementation, which is a mandatory stage of evaluation. We demonstrate how to employ FOI using data from a secondary school in Singapore that had devised a new curriculum to promote interest and knowledge in science. Results showed that there were ambivalent student responses to this programme in contrast with high levels of science process skills instruction, quality delivery of teaching, and close alignments with the intended lesson design. While this programme appeared to have a satisfactory overall level of FOI, we also found some tensions between programme intent and everyday classroom teaching. If we want to advance science education, then applying FOI criteria is necessary when evaluating all curricular innovations, not just those that originate from schools.

70. 04-F5

CASE STUDY APPLIED THOMAS YOUNG'S HYPOTHESIS FORMULATION PROCESS THROUGH ANALOGY ABOUT THE INTERFERENCE PHENOMENON OF LIGHT

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The study of the process that creative scientists in history found a scientific problem and formulated a hypothesis in order to resolve it can actually have many implications for developing students' problem finding ability and hypothesis formulating ability. In this study, to explain the interference phenomenon of light which was well known as a scientific problem at that time, we analyzed Young's hypothesis formulation process using Young's treatises and papers on light in 1800 ~ 1807 and applied this thinking process to students. when the corpuscular theory of light dominated, Young was so forcibly impressed with the resemblance of sound phenomena to light phenomena and formulated a hypothesis through analogy with a sound, furthermore, with the water waves. Young's hypothesis formulation process can be divided into 7 steps. (1) to recognize the resemblance between sound and light (2) to define light as the nature of waves (3) to explain the nature of light with wave (4) to explain linearity of light with wave (5) to find the phenomenon of sound resembled to that of light and to explain it (6) to explain the interference phenomenon of light (7) to criticize the corpuscular theory of light. the process was applied to 5 middle school students in the 3rd grade who are having more interest and excitement in science and was analyzed qualitatively students' formulating hypothesis and the features which students have at each step.

- Poster Exhibition 2-A
- Date: Thursday, October 27, 2011
- Time: 14:40 ~ 15:40
- Room: Main Room

1. P2-A1

THE STUDY OF EXPLORING ELEMENTARY SCHOOL STUDENTS' SCIENTIFIC EXPLANATION BY USING THE POE STRATEGIES

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The purpose of this study was to investigate the 6th graders' abilities in scientific explanations, and to find the difficulties and factors when students making scientific explanations. The subjects consisted of 34 6th graders in a school in New Taipei City, Taiwan. Students' scientific explanations were explored by collecting students' responses during a scientific learning activity, "Heat Conduction." A Prediction - Observation - Explanation (POE) approach was adopted in the class. For the purpose of collecting research data, freehand drawing, depicting, and interviewing were used to gather students' science explanations regarding to the concept of heat conduction. The findings of the study were as followings: a) Most of students did not make use of concept of the heat conduction to making prediction. The majority of students interpreted incomplete and inadequate explanations in the POE activities. b) Most students were able to correctly depict results after observing the experiment. However, there were only a few students able to put forward the correct explanations. c) There were some difficulties when the students made scientific explanations: students lacked scientific knowledge, their concepts are not clear, or they could not use reasoning for their explanation. d) Most of students who made correct prediction, tended to maintain their original explanations after the experiment. Finally, some suggestions for science teaching and future research were proposed based on the research results.

2. P2-A2

THE EFFECTS OF SCIENCE WRITING PROGRAM ON MIDDLE SCHOOL STUDENTS' CREATIVITY AND SCIENCE-RELATED ATTITUDE.

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To live in a competitive time of science technology, we need abilities of renewing knowledge and solving problems we meet everyday in our lives. These abilities are based on our background knowledge and creative thinking. Therefore national curriculum stress the need of education for developing students' creativity and science writing is highlighted as effective learning method which is foster creative thinking ability. This study was designed to investigate the effects of science writing program on middle school students' creativity and science-related attitude, focused on the subject matter of「Stimulus and Response」and「Plant's structure and function」. Science writing program for 21 lessons were developed in biology related subject and applied to participants of this study. The participants of this study were 316 students in the 2nd grade of middle school, pre-and post-test control group was employed. The control group was designed to have a traditional lecture-based class while experimental group 1 was assigned to have the same lecture-based class followed by science writing program. Experimental group 2 was assigned to have additional feedback from teacher after the same treatment of experimental group 1, lecture-based class followed by science writing program. Test was designed to assess students' scientific creativity, and the test material was composed based on the test developed by Kim, Seung-Hoon. TTCT developed by Torrance was used to assess students' general creativity, and revised version of TOSRA developed by Fraser was used to assess students' attitude toward science. ANCOVA and two-way ANCONA were conducted together with SPSS 18.0. to attain the result. The results from this study are as followed.

The result from students' general creativity test after the appliance of science writing program was different. It was found that science writing program wasn't effective on student's general creativity development. But science writing program followed by teacher's feedback had a meaningful effect on two subunits of general creativity, originality and elaborateness($p < .01$). And there was no differences in general creativity affected by gender and educational achievement. As a result from the students' scientific creativity test, science writing program with teacher's feedback was fortified students' scientific creativity($p < .01$). Science writing program with teacher's feedback was effective on flexibility development($p < .01$), but was ineffective on elaborateness and originality development. The effects on scientific creativity of science writing program had no differences between the sexes and no differences among three subunits of creativity, either. Also, students who gained high achievement in science were more influenced on their scientific creativity than others through science writing program with teacher's feedback($p < .05$). And each of three subunits of creativity were improved with influence of science writing program with teacher's feedback, especially for students who had mid or high-level achievement($p < .05$). The result from students' attitude toward science test after the appliance of science writing program showed no significant effect. The program helped students to improve their attitude toward scientific inquiry, interests on science as a hobby($p < .01$). Still, it was not effective on other aspects of attitude such as social signification of science, the standards of scientists, application of scientific attitude, the pleasure of science class and concerns about professions related to science. And there was no differences in students' attitude toward science after the use of the science writing program affected by gender and educational achievement. The study result revealed that science writing program improved scientific creativity of middle school students. Therefore science writing can be used as effective teaching strategy for scientific creativity development. The use of science writing program can be effective for both genders. And especially for the students of high-level achievement, the effect of science writing prog6ram was amplified by teacher's feedback. The findings of this study suggest that using test for scientific creativity is more suitable than that for general creativity. Since there's still in short supply of test for scientific creativity, it is desirable to develop scientific

creativity test which is standardized and can be easily used by teachers. And it is required that more and deeper studies on not only cognitive aspect but also affective aspect of creativity should go on.

3. P2-A3

ANALYSIS OF LABORATORY ACTIVITIES IN HIGH SCHOOL BIOLOGY TEXTBOOKS USED IN CHINA AND KOREA

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The purpose of this study was to examine laboratory activities incorporated in high school biology textbooks used in China and Korea. Laboratory activity is a major source of student investigation which both of the national curriculum standards strongly emphasize for achieving scientific literacy. The laboratory activities were analyzed with regard to inquiry level and science process skills. The results show that the majority of the laboratory activities analyzed were at low levels of inquiry. However, the Chinese texts provided a few laboratory activities characterized as more open, whereas none of the laboratory activities in the Korean texts was determined at more than level 3 inquiry. The Korean textbooks provided more monotonous science process skills, compared with their Chinese counterparts. One of the reasons why the texts of both nations had a high proportion of low level inquiry might be that they, as a great merit of inquiry learning, are placing more of an emphasis on effective learning of scientific concepts than cognitive development and scientific reasoning.

4. P2-A4

THE RESOURCE DEVELOPMENT AND APPLICATION OF VISUAL-ANALOGICAL LEARNING FOR UNDERSTANDING CONCEPTUAL LIGHT AND WAVES FOR MIDDLE SCHOOL STUDENTS

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Visual-analogical learning is very effective for students who have difficulties with science by explaining new science concept together with familiar objects. Extensive research has described the figuration acts not only helping to understand conclusions from the abstract scientific concepts to common terminology, but also acts to expedite creative thinking skills from identification of a new problem and hypothesis. The purpose of this study was to develop and apply the visual-analogical learning model for middle school students via the concepts about light and wave, which is based on theoretical research of visual thinking and analogical learning. This study investigated the effects of the visual-analogical learning on students' creativity, science achievement and interest in middle school science.

5. P2-A5

DEVELOPMENT OF THE TASK-BASED ASSESSMENT TOOLS FOR SCIENTIFIC CREATIVITY (TATSC)

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The purpose of this study is to develop and to apply the task-based assessment tools to select students with scientific creativity. To do this, we developed 15 TATSC (Task-based Assessment Tools for Scientific Creativity) based on Park's model of scientific creativity (Park 2004) consisting of nine elements of scientific creativity (fluency, flexibility, unusual thinking, coherence, synthesis, simplicity, associative thinking, originality, and elaboration). Here, 'task-based' means that students are asked to perform a given task for relatively long time (about 3 hours), to make a performance report, and to give oral presentation. When measuring the face validity of the TATSC from the five professionals, the result showed high degree of the face validity. To assess students' creative ability, we defined each element of scientific creativity operationally. Then, assessors observe students' performance process by checking the scoring card and give the rate of their performance report and their oral presentation. To help assessor, we developed guide about how to give a mark on the scoring card. When applying the developed TATSC to students, an average of inter-rater reliability of three assessors was 0.90, and internal consistency items' average was 0.80. Therefore, evaluation criteria of TATSC has been reasonable and consistent. And it can be said that the scorning system was objective. The level of difficulty for each element of scientific creativity was 0.24~0.72, and the average of task discrimination appeared 0.22~0.28. As a result, we confident that the developed TATSC can be used for measuring scientific creativity in school system with high validity and objectivity.

6. P2-A6

NEEDS FOR 3D TEACHING MATERIALS IN HIGH SCHOOL BIOLOGY TEACHING

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Spatial abilities are closely correlated with success in science learning of certain kinds of topics and areas, such as chemistry, physics, mathematics and geology. While 3D teaching materials have been already proved to serve as efficient aids for students' learning in various fields of science such as electricity, mathematics, geology and astronomy, few studies, so far, have been reported on 3D materials for high school biology education. This study investigated what are difficult units or topics to learn without utilizing 3D teaching materials in high school biology in Japan and discussed the effects of learning with 3D teaching materials. For that purpose, first, we identified high school biology teaching units or topics, where 3D teaching materials are actually utilized through discussion with members of Biology Teachers' Association of Tokyo and then we developed and administered new questionnaires on 3D teaching materials for high school biology in order to confirm biology teachers' needs and identify specific units appropriate for the use of 3D materials. The results indicated that among others the teaching units, embryonic development, and protein synthesis were nominated as promising units for utilizing 3D teaching materials. We will also present examples how such 3D teaching materials are working in real class settings.

7. P2-A7

UNDERSTANDING ABOUT THE PRINCIPLE AND THE DONATION OF HIGH SCIENCE AND TECHNOLOGY THROUGH RESEARCH ACTIVITY OF THE INVENTIONS

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This research is a result of research activity of the inventions for middle school students of Busan by science education research center of Pusan National University and is a service project of science and technology for local community supported by Busan Metropolitan City Office of Education. Most middle school science classes work at repeated solving problems for confirming the science principles. This type of science education affects students to limit the understanding of the wide varieties of science applications and is directly reason for students to feel difficult. During this development the service project of science and technology for local community, we reflect the problem of science education and give students a chance to research activity of the inventions. The research activity is constituted of investigating the science principles of high technology application and understanding the donation of science and technology to society. In this research, we have adopted two inventions which were high-end mobile phone using gyro-sensor and self-adjustable multi-focus eye glass for people who live in hinterland. Students directly experienced the principle of rotational motion which applied gyro-sensor in mobile phone and made multi-focus lens for themselves. By researching these activities, students should be able to understand the adopted principle of the high science technology and the way to improve a global world.

8. P2-A8

A MODEL FOR THE TEACHING OF COLUMN SEPARATION SCIENCE

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The aim of this project is to develop a simple system that can be used to demonstrate the concepts and techniques of column chromatography to students from high school to university level. The system uses commonly available materials and apparatus, and complete experiments can be carried out within the time-frame of school laboratory-based lessons. A simple, cheap and reliable way to synthesize agarose microbeads for use as the stationary phase in a column is described. Mixture of dyes are also identified and optimized so that they separate cleanly into distinct bands in the column, and are therefore suitable for demonstration and student-led experimentation purposes.

9. P2-A9

PERCEPTION AND DIFFICULTIES OF TEACHERS AND STUDENTS ON THE EXTRA-CLASS SCIENCE ACTIVITIES OPERATED AT SCIENCE CORE SCHOOLS

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The extra-class science activities in the curriculum for the 'Science Core School' which started in 2010, belongs to the informal science education for the high school students. Informal science learning offers opportunity to develop science knowledge and helps to mitigate the loss of science knowledge acquired. By achieving the balance between formal and informal learning, students will develop rich and productive notions of life-long learning. Informal science learning becomes an even more important part of the educational landscape as the students grow older, especially if they do not choose a vocational career in science. There were some researches about the out-of-school settings for elementary school students in Korea, but there was no report about informal science learning for high school students. In this research, we investigate opinions of the teachers and students about the informal science learning of the science core schools and difficulties faced in operating the extra-class science activities. Data were collected from 538 students and 26 science teachers from 5 science core schools in the city of Seoul, Korea. The information about the extra-class science activities were collected from 'Science core school's operating plan', 'Protocol of the extra-class science activities' and the internet webpage of the school, and we received reports on the operation status of the science core schools via e-mails from science teachers of the school. And also, we have participated in the extra-class science activities of one of the science core schools, which is being operated for all students. We analyzed the extra-class science activities which are occupying large portion of extra-curriculum activities of the school hours. This paper will help science teachers being in charge of leading the students to develop their scientific literacy.

10. P2-A10

THE APPLICATION OF THE PROBLEM-BASED LEARNING MODEL FOR SCIENCE UNIT "ENVIRONMENT" AND ANALYSIS OF ITS EFFECTS

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Problem-based learning (PBL) is a constructivist pedagogy in which students learn in small groups by working on real-world problems. The purpose of this study was to develop 'the problem situations' for the PBL and to examine the students' perception on this model. Also it's effects on the science achievement and the attitude towards science learning was examined. The topics of the problem situations developed were 'the future energy for reducing the green house effect' and 'the Indonesian rain forest fire and the El Nino'. The teaching strategies for the PBL were designed and implemented to 10th grade high school students for the science unit "environment". The steps in the PBL process of this study were as follows: 1)presentation of the problem situation 2)confrontation of the problem situation 3)know/ need to know 4)definition of the problem statement 5)collection and sharing of information 6)generation of possible solutions 7)assessment of the best fit of solutions 8)presentation of the solution. The study obtained the following conclusions: group discussion in the know/need to know step was most helpful for students to review what they know and generate solutions. At first, students tended to state problems widely but through repeated group discussions they gradually clarified the problems. In the students' personal reflection notes and perception questionnaire of PBL process, many students especially showed difficulties in defining the problem statement. In contrast, they participated actively in the learning process and express their opinions enthusiastically. Also, science learning performance and attitude toward science in the experimental group who participated in PBL classes were superior to those of control-group learners who participated in traditional classes. Therefore, this study suggests that developing the problem situations based on real context is of great importance for implementing PBL model continuously.

11. P2-A11

THE TRANSFER OF COMPETENT STUDENTS' PROBLEM SOLVING STRATEGIES IN GRAPHS TO A TEACHING MODEL IN SENIOR HIGH SCHOOL PHYSICS

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The purpose of this study was to investigate competent senior high students' problem solving strategies when reading graphs in physics and transfer these strategies into a teaching model to explore its effectiveness. Thirty-seven students whose PR value (percentile rank value) in the entrance exam was about 76 were invited to participate in this study. In the first phase, three competent students were chosen to investigate their problem solving strategies in graphs and think aloud method and Repertory Grid Technique were used to explore the strategies. In the second phase, all these strategies were transferred into a guided question-posing teaching model. The model consists of analytic, synthesis and comprehensive questions to propose when teaching graphs in physics. The results of students' achievement tests in three following exams every two weeks showed significant improvements in the statistical test of chi-squares. It is implied that the question-posing teaching model can be a potential strategy when teaching graphs in physics.

12. P2-A12

A STUDY ON TEACHER'S AWARENESS OF QUESTIONING AND TEACHING PRACTICES IN ELEMENTARY SCIENCE CLASS

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We investigated the types, frequency and characteristics of questions asked by teachers in elementary science class and the relationship between their awareness of questioning and teaching practices. It specifically meant to check into the reason why open-ended questions were rare in elementary science class. We analyzed three elementary school teachers' science classes to find out the types and characteristics of teachers' questions and interviewed them to identify teacher's awareness of questioning. According to study, the teachers used frequently asked cognitive-memory question and convergent thinking question, which belonged to closed questions. An interaction which was just relied on a series of questions and answers, might just contribute to the revival of memory without fostering higher thinking ability such as analytic thinking ability, critical thinking ability or creative thinking ability. And the teachers considered it important to ask questions in elementary science class, but they didn't have a good understanding of questioning. All three teachers just knew that there were largely two different types of questions involving closed and open-ended ones, but they got confused between closed and open-ended ones. It's required to provide in-service education or training for teachers to wake up to the importance of questioning and to learn about the types of questions and ideal ways of questioning. Experiences and training enabled the teachers to put what they learned into practice in class. Two teachers weren't well experienced nor well trained in questioning, but a teacher got to see questioning in a new light by taking training courses, and came to ask questions in a different manner. Therefore more practical training courses should be provided instead of theoretical education in order for teachers to practice questioning and realize the effect of questioning. The questioning of the teachers was under the influence of their awareness of the objectives of science instruction, their knowledge and experience of questioning, preference for science class and time constraints. All the factors made it hard for them to ask open-ended questions in science class. Therefore we suggested that in order to improve the efficiency of questioning to foster the thinking faculty of students, better educational setting should be created, and teachers should be given more opportunities to take training courses in questioning.

13. P2-A13

EXPLORATION OF ENERGY UNIT OF KOREAN SCIENCE TEXTBOOK FROM AN VIEWPOINT OF 21TH CENTURY SCIENTIFIC LITERACY

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Scientific literacy has become the goal of the science education during the last seventy years. We, however, need to consider for our student living in the new generation. In the 21st century, the context of confront problem expanded to the global situation. Recently, the

re-conceptualization of the scientific literacy for the 21st century is reported (Choi *et al*., 2011). The 21st century scientific literacy has five dimensions (habits of mind, character and values, science as human endeavor, meta-cognition, scientific knowledge). Each dimensions consisted of three sub-dimensions. The Most of countries emphasis scientific literacy for the 21st century on the national curriculum. The purpose of this study is to explore contents of Korean science textbook energy unit and to examine the contents using 21st century scientific literacy rubric. Therefore, we developed 21st century scientific literacy rubric with the use of the re-conceptualization and applied it to seven Korean science textbook. The scientific literacy rubric involved three dimensions except meta-cognition and scientific knowledge. Three science education experts assessed contents of textbook using the developed rubric. The reliability within examiners has calculated. We discussed about issues that did not match between examiners and reached an agreement for all assessment. As a result, we found that most of Korean textbook involved contents about habits of mind such as communication, collaboration, and information management. We also found that there is not enough contents about character and values and science as human endeavor. In conclusion, we suggested that researchers and science educators need to consider all of the dimensions of 21st century scientific literacy when they develop curriculum and teaching materials. In addition, the rubric of 21st century scientific literacy can be adopted for assessment tool for examine curriculum, teaching materials and students ability. Choi *et al*. (2011), Journal of Research in Science Teaching, in press.

14. P2-A14

HIGH SCHOOL STUDENTS' PERCEPTION AND APPLICATION OF PHYSICS FORMULAE

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The formulae in physics are one of the causes that a lot of high school students in Korea have some difficulties to study physics. Based on this reason, the number of formulae are decreased in the physics textbooks nowaday. However, the formulae take very important role for understanding the physics. In this study, we found how the high school students recognize the formulae in physics and how they apply the formulae to solving problems in physics study. We classified the formulae presented in physics textbooks, and interviewed 20 male and female high school students who were learning physics. In the results of this study, the students' perceptions of the formulae in physics are classified into two groups. First group perceive the formulae as the method to explain the physical nature, while the other group perceive that the formulae are simply the tools to solve the problems in physics. According to the analysis, there are some differences in solving problems between two groups. We find the elements affect the recognition for formulae, and we suggest the new arguments about the understanding of the formulae and teaching-learning method in physics.

15. P2-A15

EXPLORE GIRLS' SCIENCE SELF-EFFICACY BY ASTRONOMY SYMPOSIUM

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The main purpose of the Cornerstone project, She Is An Astronomer, in the International Year of Astronomy 2009, was to address and tackle the gender-imbalance in astronomy as well as science, which is heavily affected by social and cultural factors, and is not determined solely by ability. Based on this background the astronomy symposium, which held on eight weekends, every third or fourth weekend throughout a school years, was conducted in support of girls' science self-efficacy research. This paper describes the symposium program including hands-on activities, star gazing practices, do it yourself model making, and learning contests, which designed to improve girls' science self-efficacy. Forty-two 7th-graders in the girl-school in southern Taiwan involved. A questionnaire was developed and used to investigate students' science self-efficacy and reduce the number of items by eliminating, we obtained 4 factors, there are Classroom Climate (CC); Science Self-Efficacy (SS); Interesting Arousal (IA); Achievement / Motivation (AM). The Cronbach's alpha coefficient of .93 indicated that the reliability of the survey was very good. Then, an explorative factor analysis ,Pearson correlation analysis, and regression were performed. The results showed that female students responded highly positively to the factors, because the means of each self-efficacy factor are located 4.98-5.27 in five scales; Achievement/Motivation strongly influences Science Self-efficacy, because the Pearson's correlations among the four factors are all statistically significant ($p<=.001$). And the correlation coefficients indicated moderate ($0.60>r>0.39$) to strong ($0.80>r>0.59$) correlations among all factors. It is noteworthy that Science Self-efficacy, Classroom Climate, and Interesting Arousal are strongly correlated to Achievement/Motivation. So Classroom Climate, Interesting Arousal, and Achievement/Motivation have significant positive correlation with Girls' Science Self-efficacy. We also do a multiple leaner regression model was proposed that Science Self-efficacy could be influenced by the three other factors. That is $SS= a + b \times CC+ c \times IA + d \times AM$, where a is a constant, b ,c and d are coefficients. Achievement/Motivation does influence Science Self-efficacy. And the model may be written as follow, $SS=2.017 + 0.605\times AM$, where the constant and the coefficient are significant at the 0.005 and 0.000 level. The ANOVA test rejects the null hypothesis, indicates that Classroom Climate, Interesting Arousal as well as Achievement / Motivation significantly influence Achievement / Motivation. These findings suggested that providing opportunities of achievement and supports of motivation, creating a friendly classroom climate, and arousing students' interesting in the class will benefit girl students in science self-efficacy.

16. P2-A16

EXPLORE ELEMENTARY TEACHERS' PROFESSIONAL KNOWLEDGE OF GUIDING SCIENCE FAIR PRODUCT BY USING DIFFERENT INSTRUCTION MODELS

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This research is about using two different instruction models, "Theory course combine with sample introduction" and "Theory course combine with case method teaching", to instructed elementary teachers how to guide the science fair product in two courses (16 and 12 teachers in each classes) and observes their guiding tactics after the instructed classes. The result show: 1. Elementary teacher's who has taken the "Theory course combine with sample introduction" course consider: (1) Introducing the samples can let them clearly understand the process of how to guide students to do their science fair project. (2) Teachers can follow the description sample to make their science fair project topic, extend these topic form original science courses, draw the conception map and flow table, handle the scientific experiment, and then teach student to be familiar with the content of science fairs project. 2. In-service teachers which have chosen the "theory course combine with case method teaching" course consider: (1) Case-method teaching helps them understand the contents of the curriculums; (2) It provides them models to observe and imitate. With such an increase of awareness, knowledge transference had brought out. Thus professional knowledge would be promoted. Both teachers who have accepted these courses had hiatus when guiding students developing their product: 1.Teachers is inadequately comprehending the basic scientific theory of subjects of their science fair project; 2.Scientific verification is not scientificalness; 3. Verify facts which is already known; 4. Careless about the control variable.

17. P2-A17

"FINDING N.E.M.O." IN THE SCIENCE CLASSROOM: A FOUR-STEP APPROACH TO EFFECTIVE LESSON PLANNING-IMPLEMENTATION

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Good lesson planning must be followed by effective implementation of the plan. In this poster presentation, a four-step approach is considered in which teachers are encouraged to (i) identify the learning (N)eeds of their students, (ii) set realistic but progressive (E)xpectations, (iii) commit to effective (M)anagement of the students' learning experiences, bearing in mind to align teacher's expectations to the students' learning needs, and, and finally (iv) evaluate the students' learning (O)utcomes from the lesson taught. The acroynm, N.E.M.O. is not only easy to remember because of the Disney/Pixar animated film by the same title (released in 2003), but also allows the teacher to plan and conduct the lesson smoothly and successfully. A detailed screening of the entire animated film actually surfaced five useful short clips where the storylines illustrate some of the critical characteristics of scientists and good science learners. The use of the acroynm (N.E.M.O.) was made known to the Disyney/Pixar master licensee in Singapore, which generously agreed to the author's sharing of this idea in educational settings.

18. P2-A18

THE GAP BETWEEN PRE-SERVICE TEACHERS' IMPLICIT KNOWLEDGE AND PRACTICAL KNOWLEDGE ON IMPLEMENTING ARCS MOTIVATING STRATEGY

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This study explored the gap between pre-service secondary science teachers' knowledge and practice on the ARCS motivation strategy (Keller, 1987) during teacher internship program, and the relationship between this gap and barriers to achieve desired teaching goal. Three pre-service secondary science teachers had been taught 'the human reproductive organ' and participated in this study. Data were collected using a questionnaire, semi-structured interview, and video-tape of classroom teaching, and were analysed for revealing participants' self-reflections on teaching, their knowledge and practice on ARCS motivation strategy. The study showed three participants tried to apply almost every component of ARCS Model ; Attention, Relevance, Confidence, and Satisfaction except Confidence, even though their knowledge on each component is limited to some extent. In addition, participants reported their challenges on achieving desired teaching goals when they did not perform certain ARCS component and failed to motivate students. Based on the current research, the way for teacher education how to develop teachers' implicit knowledge on practice to the practical knowledge on teaching strategy is discussed.

19. P2-A19

A CASE STUDY OF AN EXEMPLARY SCIENCE TEACHER'S PROFESSIONAL DEVELOPMENT

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The major purpose of this study is to explore an exemplary science teacher's professional development. Case study research method was used in this study. Subject of this study is a retired elementary science teacher who is still enthusiastic in participating and promoting elementary school science education. He run an elementary science education center after his retirement, which is kind of like a cram school, and provide science education programs for elementary school teachers and hands-on science activities and field trips for school pupils. Interviews, workshop observation, and related documentations were collected and analyzed. Major findings were include: (1) the reception of continuous encouragements and successive positive feedbacks from students or other peer teachers has strongly influenced teacher's attitudes and behavior on professional development, (2) activities from workshops did improve teacher's teaching ability and confidence, (3) strategies on promoting science teacher's professional development were discussed, and (4) strategies on improving science education at elementary school level were discussed.

20. P2-A20

A CASE STUDY OF INTEGRATED SCIENCE INSTRUCTION BY PRE-SERVICE SCIENCE TEACHER APPLIED SCIENCE INSTRUCTIONAL MODELS

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This study is aimed to investigate pre-service teachers' challenges in applying integrated science into science instructional model, and further, to present a way to improve professionalization of science teaching. The findings of this study are as follows. First, the teacher group who chose discovery learning model had difficulties in matching the class topics with the science instructional model. Since the science instructional model did not fit the class topics, it was hard to apply integrated scientific factors and impossible for the class topics to present each characteristic of science instructional model. This example of the discovery learning model group suggests the importance of the fitness between a instructional model and a lesson topic. Second, it was revealed that organic connections between Science subjects were essential in building course contents and processes. To achieve the integrated science instruction's goal by synthesizing irrelevant concepts into one topic, the connections among each concepts are important. Third, the teacher capability required for the Integrated science instruction is as follows. For the instructions of conceptual changes, teachers' questioning is required to encourage students' cognitive conflicts effectively. As for the instructions of inquiry learning, teachers are required to minimize their participation in designing and leading experiments, while students are required to pursue active self-directed learning. Moreover, in STS instructional model, which consists of series of discussions, teachers are required to introduce a proper manner of discussion as well as take a role as a balanced moderator. Fourth, the order of presenting story - principle(method) - example was effective when the integrated scientific factors were applied to science instructional model. In other words, the order of 'leading and backing up lessons'- 'main lessons'- 'examples of applied current technology / culture' was revealed to be an effective way to realize the instruction that fulfills the goal of Integrated Science.

21. P2-A21

A STUDY ON THE RECOGNITION AND REQUIREMENTS ON THE INTEGRATIVE STEM EDUCATION

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The Purpose of this study was to survey the recognition and requirement for Integrative STEM education. The questionaries has been developed based on the precedent studies on the Integrative STEM education. Two hundred sixteen elementary school teachers have participated for this study. As a result, (1)teachers frequently used shared model, webbed model, sequenced model of Integrative education models by Forgaty. The teachers had difficulties on Integrative education because of a burden of preparation Integrative class, a insufficiency of expertise for Integrative class, a insufficiency of materials and reference for Integrative class. (2)Though most of them did not have knowledge of the Integrative STEM education, they agreed on the need of Integrative STEM education. (3) Teachers agreed on that the relative program developments and teachers' understandings should be preceded to implement the Integrative STEM education.
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- **Poster Exhibition 2-B**
- **Date: Thursday, October 27, 2011**
- **Time: 14:40 ~ 15:40**
- **Room: Main Room**

22. P2-B1

A NEW ASTRONOMY EDUCATION WEB SITE FOR CHILD-CARE SUPPORT PEOPLE

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I started a project including a new web site where child-care support people including teachers and parents exchange and develop idea of astronomy education for children especially in informal settings. I have visited a nursery school in Osaka Prefecture, Japan, and enjoyed “star and sky play” with 3, 4, 5-year-old children and their teachers and parents, and I have observed the nursery children in detail. However, it is not easy that the results be shared with other nurseries and groups which help the child care. The reasons are that the field of star and sky is not so popular to preschool teachers and that in Japan not all preschools are strongly under the control of the bureau which can have a well-organized information system. The web site which has science education supervisors can solve this problem. I will present a preliminary version of the web site.

23. P2-B2

DEVELOPMENT OF PROFESSIONAL COMPETENCY INDICATORS FOR MATHEMATICS PRE-SERVICE TEACHERS IN TAIWAN JUNIOR HIGH SCHOOLS

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The purpose of this study was to develop the professional competency indicators for Mathematics pre-service teachers in junior high schools to provide substantive suggestions for the Mathematics teacher education programs in Taiwan. Based on the conceptual framework of IEA TEDS-M (International Association for the Evaluation of Educational Achievement, Teacher Education and Development Study in Mathematics), a questionnaire designed by analysis hierarchy process (AHP) was utilized in the expert surveys for mathematics education scholars and professors in the institutes of teacher education and senior mathematics teachers in junior high schools. The system of professional competency indicators contained 2 levels, 8 dimensions and 30 evaluation criteria. The study found that the level "Mathematics teacher's knowledge", the dimensions "Mathematics content knowledge" and "Mathematics pedagogy knowledge" and the evaluation criteria "enacting Mathematics for teaching and learning" and "knowledge of planning for Mathematics teaching and learning" are top ranking in the system.

24. P2-B3

EXAMINING PRE-SERVICE PHYSICS TEACHERS' CONCEPTUALIZATIONS OF TEACHING ABOUT LIGHT PROPERTIES

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The paper aimed to examine pre-service physics teachers' conceptualization of teaching about light properties. The participants included 5 pre-service physics teachers who enrolled in 232423 Physics Learning Management of Khon Kaen University. Participants' conceptualizations of physics teaching were interpreted through Loughran, Berry and Mullhall (2006)'s Content Representation (CoRe). The finding revealed that they could not recognize holistic view of knowledge for light properties teaching. The paper will discuss how to support them developing pedagogical content knowledge for this topic.

25. P2-B4

TEACHER'S RESPONSE CHANGE TO STUDENTS' INCORRECT ANSWERS IN EARTH SCIENCE CLASSROOM

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Teacher talk has been the focus of many investigations over the years. Even if many teacher talk studies did not expose explicitly which talk pattern was more proper approach to science classroom discourse, there were implicitly some assumptions that teachers were expected to change their classroom talk patterns qualitatively and develop them more meaningful for student learning. Teachers' talk pattern described the moves in the I-R-F(or E) structure, which referred to an initiation by a teacher that elicits a response from the student, to be followed by feedback(or evaluation) from the teacher. In this structure, teachers' response style which is feedback or evaluation can be a one of indicators to show how they are interact with their students. Teacher's response to the students' incorrect answers differ among teachers. Some teachers answers his or her own question; others re-asked, while others asked meta-cognitive questions. Especially, questions to encourage students to express their own ideas (for example by asking, "How did you know that?" "Why?"), this does develop students' high-level comprehension skills. And recently, action research has got noticed appropriate and powerful as an approach to teacher's professional development and change. Especially collaborative action research between teacher and academic researcher is becoming an increasingly recognized field of educational research. Thus this study conducted collaborative action research which focused on the teacher talk style in science classroom. Teacher's teaching practice and researcher and teacher discussion were recorded and analyzed. Finally teacher's response change to the students' incorrect answers in high school earth science classroom will be illustrated as a result of collaborative action research for 3 months.

26. P2-B5

KOREAN SCIENCE TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE (PCK) REPRESENTED IN TEACHING PRACTICE AT MIDDLE SCHOOL CLASSROOM

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The purpose of this study was to investigate middle school science teachers' Pedagogical Content Knowledge (PCK) represented in instruction and by other influential factors. For this study, 3 teachers were chosen as subjects. The data of this study were collected through qualitative research methods, such as semi-structured interviews, classroom observations and CoRe questionnaires. Data were analyzed by using a constant comparative method after transcription. In this study, one of the participant's (Kim) PCK was characterized as being inquiry-driven teaching. Another participant's (Ryu) PCK, was characterized as having an orientation towards activity-driven teaching Another teacher's (Park) PCK was characterized as having a didactic orientation for transmitting the facts of science. The three teachers' PCK that were represented in science classes were affected by the teachers' own practical experiences, textbooks, and learning materials. But their PCK was not affected by their university studies and their teacher training program. From these results, it was concluded that understanding learners was a very important component in developing teachers' PCK. The teaching experiences were main factors in understanding their learners. Therefore, it is suggested that teacher education programs for pre-service and in-service teachers need to design programs that develop teachers' PCK.

27. P2-B6

WHY WE NEED BETTER PEDAGOGICAL APPROACH PHYSICS EDUCATION IN KOREA: A CASE STUDY OF IN-SERVICE TEACHERS' DIFFICULTIES IN ELECTRICITY

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This paper explores the development of tutorial emphasizing on movement of charges, and to analyze the changes from teachers during implementing tutorial. We did preliminary research to determine the elementary teachers' specific difficulties and misconceptions about electrical currents. In the following results from preliminary research data we developed tutorial and implemented for In-service teachers. Multiple-choice questionnaires on the concept were given before the tutorial and after completing the tutorial, multiple-choice questionnaires were given again. This means that how much have the tutorial contribute to teachers to lead scientific conception of electrical currents. To better observe some of the specific changes teachers make, all activities of tutorial were recorded and transcribed to identify in-depth teachers' changes. We strive to analyze teachers' change in conceptual understanding qualitatively as well as quantitatively through the tutorial. We obtained these conclusions after analyzing their conceptual changes in electricity. When the educators understood the characteristics of conductors and insulators, they were able to explain friction, induction, and the movement of charges at contact points. This ended the confusion between electric charge and current. Though many teachers responded that there was no voltage between current did not flow in an open circuit, their understanding of voltage and the movement of charges was better understood through the tutorial. These tutorials played an important role in correcting the idea that voltage is the same as current. By emphasizing the interaction of charges in a closed circuit, the teachers understood that current was not consumed but remained constant. Also, the tutorials corrected the misconception that the battery produces constant current in all situations; instead, the teachers began thinking in terms of the movement of charges through a battery in a series and a parallel circuit.

28. P2-B7

THE GENESIS OF MATH AFFECT

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This study determined when students' math affect came into being. The researcher asked 203 college students as to when they started loving or hating mathematics. To have a deeper understanding of the causes of math affect, the respondents were also asked how they started feeling as such towards mathematics. Thematic data analysis was used in processing the data. The results showed that most of those who loved math (51.9%) started loving the subject when they were in elementary school but most of those who hated math (49.4%) started hating it when they were in high school. Teacher factor was found to be instrumental in developing both love and hatred for math. Natural ability and parents were also found influential to developing love for math. Failure or low grade in mathematics was the second most influential factor in developing hatred for math. A more careful analysis on these results would give educators idea on how to encourage math love and discourage hatred for math.

29. P2-B8

TOULMIN'S APPROACH TO DEVELOP NEW TEACHING STRATEGIES OF ARGUMENT-CENTERED SCIENCE LEARNING

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The structured program is recommended to implement authentic scientific inquiry in the classroom by creating authentic environment, where students learn scientific concepts, develop inquiry skills, experience the nature of science and scientific inquiry, and understand the relationship among Science-Technology-Society. History, research, and experiment based teaching and learning are general approach to experience the science inquiry. However science inquiry is difficult to use in context based learning class. The researchers implemented Toulmin's approach to develop new teaching strategies of argument-centered science learning, where students frame their own different questions to be explored from one theme given by textbook. For honored level chemistry class, several subjects are analyzed and designed with Toulmin's scheme. Nature of science is also stressed. We present several analyzed subjects, such as, acid-base, effective nuclear charge, and counting valence electron from octet to 18 electron rule.

30. P2-B9

EXPLORING SECONDARY PRESERVICE EARTH SCIENCE TEACHERS' ABILITIES OF DEVELOPING INQUIRY QUESTIONS

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To meet the goal of scientific literacy at modern times, it is critical for students to experience science as inquiry in the classroom. Then, preservice teachers in teacher preparation program are qualified to teach science as inquiry? The purpose of this study was to explore preservice teachers' abilities of developing inquiry questions and designing investigation first and find out their relationship. There were 4 steps for this study; (1) Twenty two preservice teachers developed their own three different inquiry questions on the basis of observing phenomenological event from the content of earth science. (2) Then participants

filled out one questionnaire which is called 'inquiry question development guide' (IQDG), where participants experienced 9 different processes to check their prior knowledge related to the given phenomenological event and re-analyze the given phenomenon with different aspects, such as what new results can be predicted, what variables can be altered, what relationship between variables can be explored, what modification can be added to the prior experiment and so on. (3) Then participants framed three different inquiry questions again after experiencing IQDG, finally (4) participants designed the investigation according to different level of inquiry questions; one was low level and the other was high level. It took around 2 hours for participants to fill out the questionnaire (IQDG) and design the investigation. The results were as follows; first, participants' abilities of developing inquiry questions were enhanced with the use of IQDG in its quality. The 'preciseness' of inquiry questions was scored higher significantly, while its 'level' was not. Second, the most frequently developed inquiry type by participants was 'why/how it worked out' type and the most second was 'what relationship between variables can be inferred' one. Third, high level of inquiry question led participants to design the higher level of investigation than that of low level of inquiry question. In concluding this result, the effect of using IQDG was positive, indicating that preservice teachers' abilities of developing inquiry questions can be promoted by the processes where they can analyze the give phenomenon with different steps, which implies that explicit teaching strategy with the use of IQDG is advised to equip preservice teachers' abilities of teaching science as inquiry. More than anything else, there was strong evidence that good quality of inquiry questions can guarantee the quality of designing the investigation in terms of making hypothesis, selecting appropriate variables, designing experiments with certain condition for terminating it and so on. The implication can be made in teacher education, focusing on teacher preparation program at universities so that preservice teachers can be qualified to teach science as inquiry with the use of IQDG.

31. P2-B10

MOTIVATION FACTORS AMONG NON-SCIENCE STUDENTS

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Third year college non-science students in food microbiology class were exposed to an eight hour laboratory work and an hour lecture . Observations suggest that students are less motivated for subjects outside their major. We report on research that examines factors that motivate non-science students to engage in meaningful learning. Science motivation was measured using Science Motivation questionnaire. Final term grades were correlated with their level of motivation. Quantitative data were triangulated with the qualitative data obtained from the reflection paper of the 30 students. Findings suggest that non-science students are motivated to study science because they want to earn good grades and are afraid to fail, to enjoy doing science at the lab, teachers who have mastery of the subject and understanding of their problems. They prefer science topics and activities which have career relevance, exciting laboratory environment, and those that develop their science skills. The research findings provide insights and implications to the preferred learning paradigm of the non-science students.

32. P2-B11

STUDY ABOUT DECISION-MAKING OF COLLEGE STUDENTS WHO ARE ENROLLED IN LIBERAL ART CLASS RELATED TO SCIENCE

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People living in 21st century are facing new situations different from the past once aimed at development of science technology only. Present science technology makes our lives comfortable but causes various problems such as moral and ethical problems with grafting variety areas of politics, economy and society. These problems are called socio-scientific issues (SSI). It is very important for general people whose major is not science, to make reasonable decision by participating various problematic situation relating to SSI on the basis of their own knowledge. They are required come in social activity based on those in modern society. Therefore, the purpose of science education for the public is to help them make informed decision. To achieve this purpose, the study offers students who are not majoring science can make decision about the SSI. Then we attempted to find out the characteristic of public's decision making in problematic situation related to SSI and try to suggest the direction of science education for the public. This study is intended for 159 students who are enrolled in liberal art class which is related to science. The topics for discussion are below. "The problem of the foot-and-mouth disease. Was stamping out best?", "embryonic stem cell research. Fors and againsts", "Nuclear power generation. Fors and againsts", "NARO spaceship, keep up or not?", "Is the global warming natural or artificial?", "Is it okay to travel Japan?-stand on the basis of continental draft theory.", "doctrine of creation and evolution." Students were divided into 21 groups which are comprised of 8-10 members according to their preference on topics and stances. Then they discussed online during 16 weeks of class and made the final decision. Students submitted the portfolios which includes the decision making process about each topics after discussion. The analysis was based on portfolios and debate process on internet. Followings are results. Students showed a tendency that they hardly get on their own claim in debate. Almost student regarded producing evidence which can back up their first opinion on the discussion as a claim. As claims were not presented, objections were not given either. Range of student thinking narrowed more and more according to the biased view. Especially, this tendency is particularly noticeable in "global warming" which has massive material. The topics "Nuclear power generation" and "NARO"'s interests clash obviously shows a tendency that they suggested method to solve the problems instead of decision making. The groups which debated about "doctrine of creation and evolution", "embryonic stem cell research" and "foot-and-mouth disease" that are related to life, tended to use religious ethics and morality for supporting justifying evidence. Students decided their pros and cons with logical reasoning about "travel Japan" which they learned in detail in curriculum and can apply to daily life. In the science education which purpose is help public make informed decision, this study shows that it is important not only to teach the method to collect evidence and make claim, but also to suggest everyday-related situation for decision making.

33. P2-B12

THE EFFECT OF EMPLOYING SCIENCE INQUIRY QUESTION DEVELOPMENT GUIDE: THE CASE OF BIOLOGY

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Scientific inquiry can be defined as the following 5 different steps; framing question, making hypothesis, collecting data, interpreting data, and making conclusions in a sequence. The first process of framing/developing question is the most critical component which guides the rest of inquiry processes into its success. However, only 2.3 % inquiry activity out of biology ones can be found in current textbooks, what is worse, science teachers had been reported that they had difficulties in guiding students to develop inquiry questions in the classroom. The researchers modified inquiry question development guide (Park, 2008) into the field of biology and 22 preservice teachers experienced seven different thinking processes necessary in developing scientific inquiry question to investigate how much their abilities to develop questions were enhanced. Participants framed the first three inquiry questions, and then they experienced the 7 different thinking processes of developing various types of inquiry questions to finalize their own three inquiry questions, one of which was designed to be investigated with the sequence of making hypothesis, collecting data with the different variables, terminating the experimentation, and so on. The results were as follows: participants developed the 'better' inquiry questions after using inquiry questions guide in terms of 'level' (1.83 per question) and 'preciseness'(1.18 per question) of inquiry questions. The most frequently developed inquiry question type was 'finding out the relationship between variables' (37%), 'designing new /modified experiments' (18%), and 'finding out why/how it worked out' (17%) in order. There was strong relationship between abilities of developing inquiry questions and designing the investigation, which means that participants who scored high in level and preciseness of inquiry questions had tendency to have high scores in abilities of designing the investigation. The 'inquiry question development guide' employed in this study can be used as one of teaching strategies for inquiry teaching effectively. Implication in teacher education can be made for preservice teachers to be equipped with appropriate understandings and practices of scientific inquiry at preparation program of universities.

34. P2-B13

EXPLORING PRESERVICE TEACHERS' ABILITIES OF DEVELOPING SCIENTIFIC INQUIRY QUESTIONS: THE EFFECT OF USING INQUIRY QUESTION GUIDE QUESTIONNAIRE

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Inquiry process is starting with framing questions and scientific knowledge is from during this inquiry process (Cho & Park, 1994). The activity framing and developing inquiry questions is very critical to guide the following step of inquiry process to find out the solutions. To make this ideal inquiry process in the classroom, it is pivotal for science teachers to perceive how to develop inquiry questions, guiding students into the authentic environment of doing scientific inquiry. Twenty-seven preservice teachers participated in this study and their abilities to develop inquiry questions were explored with the use of inquiry questions development-guide questionnaire (Park, 2008), modified into the field of chemistry. With the given experimental activity in questionnaire, participants developed their own three inquiry questions at first and experienced 9 different steps of inquiry questions type to re-produce three final inquiry questions at the end. 1 and 1/2 hour took for participants to carry out this activity. The abilities of developing inquiry questions were promoted in terms of 'level' and 'preciseness' of inquiry question after participants' experience guide questionnaire, proving that the use of guide questionnaire was very effective. The most frequently emerging inquiry type from chemistry field was 'new result' inquiry question one (34 %), 'application' type (20%), 'experimentation' type (14%), 'why'-how' type (12%), and 'relationship between variables' type (14%) in order. To create authentic scientific inquiry, it is essential for students to learn how to develop inquiry question, which can be achieved when science teachers are prepared with the appropriate understandings and practices related to implementing scientific inquiry in the classroom. The implication can be made in teacher education for preservice, beginning, and in-service science teachers.

35. P2-B14

THE DEVELOPMENT AND APPLICATION OF AN ANALYSIS FRAME OF ERROR TYPE FOR HIGH SCHOOL STUDENTS' OBSERVATION IN BIOLOGY EXPERIMENTS USING MICROSCOPES

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The purpose of this study is to develop the analysis frame of reporting observation results by high school students in biology experiments using microscopes and apply the framework. For this study, five experiments was carried out by 12 students who chose biology I as an advanced class in the academic boys' high school in B metropolitan city. Before these experiments, tests for checking prior knowledge of students were done and results of each experiment were taken picture of. Using the developed framework, the real results and reported results submitted by students were analyzed. The result of this study shows how students report their observation results and that they tend to have difficulty in doing observation activity itself. The ratio of factual reports is low because observation ways and recording ways have not been taught properly. Observation training is needed for observing real results objectively. The improvement in experiment environment is necessary for right observation, not observation for checking based on only results. In addition, the education of ethics in science research focusing on the integrity should be performed. The analysis data of reporting observation result by students can be used as basic data for teachers to plan observation strategies and to have right observation views and ways.

E·A·S·E

- Invited Workshop 4
- Date: Friday, October 28, 2011
- Time: 10:20 ~ 11:00
- Room: #1 (1F)
- Chair: Nelson Chen (National Science and Technology Museum, Taiwan)

PRACTICAL WAYS FOR TEACHING AND EVALUATING SCIENTIFIC CREATIVITY [1),2)]

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Abstract

Recently, secondary school curricula and educators have emphasized the importance of creativity in school learning. A few years ago, I developed a model of scientific creativity consisting of three axes: creative thinking, scientific knowledge, and scientific inquiry skills. Now, using this model, concrete learning materials for scientific creativity have been developed and applied to students. As a result, it has been observed that many students answered that the materials were helpful for their creative thinking, and therefore, they wanted to use this kind of materials in future activities. In these learning materials, specific guides were included to encourage students' creative activities. From the analysis of students' activities, it was also found that these guides could improve their divergent thinking, which is a kind of creative thinking. Here, I assume that creativity is more of a thinking habit than an intellectual ability. Therefore, I think that creativity can and should be taught not only to the gifted, but to students in ordinary schools. Therefore, we need to place more weight on designing a science curriculum for all students which encourages scientific creativity. To do this, I with my colleagues have recently started to develop a new model, called 'small-scale iterative experiences for teaching scientific creativity.' In this workshop, I will introduce the basic structure of the model of scientific creativity, show concrete teaching materials for improving scientific creativity, and suggest operational definitions of scientific creativity elements which can be used to assess scientific creativity. Then, participants will experience more practical ways of teaching scientific creativity in their schools.

Introduction

> *"Creativity in the arts is characteristically intensely personal and reflects both the feelings and the ideas of the artist. By contrast, scientific creativity is always constrained by self-consistency, by trying to understand nature and what is already known. ⋯ A work of art is capable of many readings, of multiple interpretations, whereas scientific discoveries have a strictly defined meaning. ⋯ artistic creations are about singular, often internal, experiences, whereas scientists strive for generality ⋯ there are objective and shared criteria for judging scientific work, ⋯" (Wolpert, 1992, pp. 56-57)*

With reference to Gardner's Multiple Intelligence Theory (Gardner, 1983), many researchers agree that creativity is domain-dependent, which means that creativity in science may have different aspects compared to creativity in art or in literature. That is, a creative scientist requires high levels of logical-mathematical and naturalist intelligence while a creative politician requires strong linguistic and interpersonal intelligences (Solomon *et al.*, 1999).

Therefore, as shown in Figure 1, I suggested a 3-dimensional model of scientific creativity consisting of three axes: creative thinking, scientific knowledge, and scientific inquiry skills (Park, 2004). If someone suggests a new experimental technique while conducting an experiment (scientific inquiry skill) using Faraday's law (scientific knowledge) by thinking divergently (creative thinking), it is said that his/her new experimental technique is invented by the virtue of scientific creativity.

DESCRIPTION OF THE MODEL OF SCIENTIFIC CREATIVITY

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1) This is written based on Park's 2004 article titled "A Suggestion of Cognitive Model of Scientific Creativity" published in the Journal of the Korean Association of Science Education, 24(2), 375-86, and Park's unpublished article titled "Development of Teaching Model and Materials for Improving Scientific Creativity in Ordinary Science Curriculum."

2) Some parts of this paper were presented at XIV IOSTE Symposium: Socio-cultural and Human Values in Science and Technology Education, Bled, Slovenia (June, 2010).

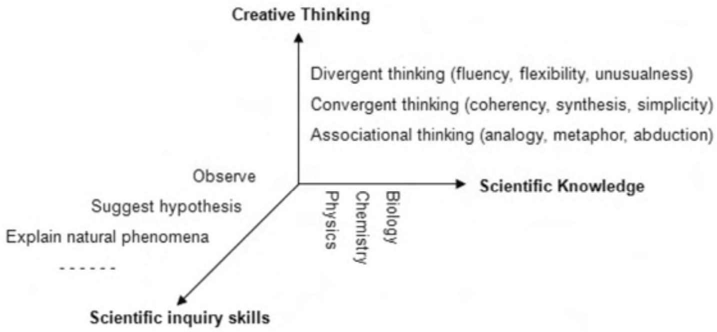


Figure 1. The model of scientific creativity (MSC)

1. Divergent Thinking

Divergent thinking can be characterized by fluency and flexibility, which are well defined as the ability to produce numerous and diverse ideas (Guilford, 1968; Runco, 1991). For example, if we ask someone to suggest ideas about the alternative uses of a compact disc, other than listening to music, the number of ideas generated corresponds to fluency and the number of categories of ideas corresponds to flexibility.

In Figure 2, the students are asked to describe the observations. In this case, the score of fluency is 6, if 1 point is given for each observation, and the maximum score of flexibility is also 6 because 2 points are given for each category of observation, where the observations are sorted into three categories according to scientific concept (the first three photos correspond to refraction, the fourth one to reflection, and the final two to total reflection).

Here, I assumed that unusualness can be the third feature of divergent thinking. Unusual thinking is defined as seeing, thinking, and acting differently from previous and traditional views, ideas, and customs. The reason that unusual thinking is involved as the third feature of divergent thinking is because there have been many instances in the history of science in which unusual thinking has led to a paradigm shift in science or a new scientific discovery. For example, the follow quote is from Hanson's analysis of the discovery process of Kepler's law:

> *"Kepler's challenge seems natural to us. But no bolder exercise of imagination was ever required: Kepler dared to 'pull the pattern' away from all the astronomical thinking there had ever been. Not even the conceptual upsets of our century of natural science required such a break with the past. Before Kepler, circular motion was to the concept of planet as 'tangibility' is to our concept of 'physical object.' ⋯ Remember, Tycho and Galileo never made this break. ⋯ Different considerations were required to convince him that it was the circular orbit hypothesis which was soiling his theory. Only when the distances given to him by the circle were repeatedly inconsistent with those observed by Tycho, did Kepler begins systematically to doubt the circular orbit hypothesis." (Hanson, 1961, pp. 74-76).*

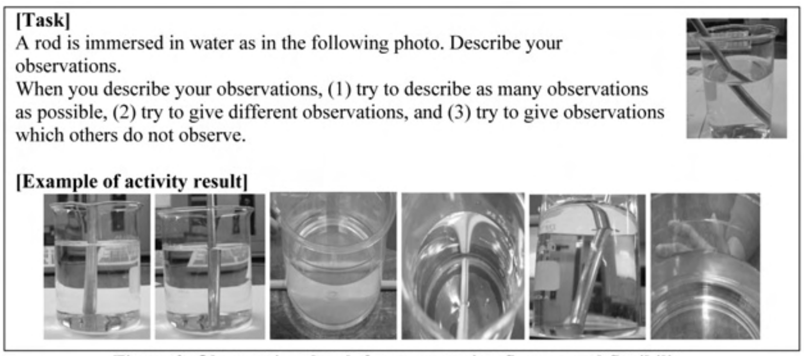
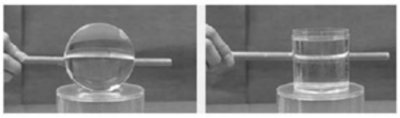


Figure 2. Observational task for encouraging fluency and flexibility

Sample activity for thinking reversely
- An LED can convert electric energy to light energy. Then do you think an LED can be used to generate electric energy using the light? (The following photo is the answer)

Sample activity for changing basic assumptions involved in scientific laws
- Ordinarily, Ohm's law is correct when the temperature of the resistor is constant. Check Ohm's law when the temperature of an LED or Nichrome wire as a resistor is increased.

Sample activity for modifying the ordinary structure of a simple scientific instrument
- An ordinary convex lens is circle-shaped. If a convex lens is modified into a cylindrical shape, what difference can be observed when an object (the rod in the figure) is moved behind the lens?



Sample activity for changing an ordinary scientific law
- If Hook's law (F = kx) is changed to $F = kx^{1/2}$, what differences does this cause compared with the original law?

Figure 3. Activities for encouraging unusual thinking

Likewise, when Dirac named the particle with negative energy, which was being neglected by most scientists at that time, an "antiparticle", or when Einstein rejected the presence of "ether" which was assumed by almost all scientists as a medium for electromagnetic waves, the common characteristic of their thoughts was unusualness.

Even though unusual thinking is not easy work, we can guide students to think unusually. For instance, the 'what if' game, such as, "What if the energy is not conserved?" or "What if the gravity of the Earth increases twice?" can be used to encourage unusual thinking. Moreover, tasks asking students 'to think reversely', 'to doubt and change basic assumptions embedded in conventional scientific concept, law, or principle', or 'to modify the ordinary structure of some scientific instrument or scientific law' can be used to encourage unusual thinking as shown in Figure 3.

2. Convergent Thinking

> *"Now it is clear that creative work often requires critical and convergent thinking as well as divergent thinking." (Runco, 1999, pp. 449-450).*

While divergent thinking corresponds to the widening and spreading out of thoughts, convergent thinking corresponds to the collecting and structuring of various thoughts. Here, I characterize convergent thinking as having the following three features: coherence, synthesis, and simplicity.

Recognition of the presence of incoherence can play a significant heuristic role because it may lead to the discovery of new ideas and revision of previous models by virtue of an effort to eliminate incoherence (Nersessian, 2002). Thagard (1997) also insists that when coherence fails, then potentially more cognitive processes are triggered and, as a result, this incoherence can lead to new discovery (Park, Kim, Kim, Lee, 2001).

In fact, Park and Jang (2005) observed that one of the three major motivators of physicists' research was a recognition of conflict (Table 1).

In the history of science, we can find many examples where recognition of incoherence has led to a new discovery. For instance, Galileo's thought experiment concerning the free fall of two stones connected by a weightless string is a good example (Fig. 4). According to Aristotle, stone 2 falls faster than stone 1 because stone 2 is heavier than stone 1. But when two stones are connected by string in Fig. 4 (b), the speed of the two stones cannot exceed 8 units of speed because stone 1 falls more slowly than stone 2. Yet, others may insist the speed of the two stones will exceed 8 units of speed because the total weight of the two stones increases. By contrasting these two views, Galileo could demonstrate that Aristotle's physics had serious internal incoherence, and to resolve this incoherence, he suggested a new idea whereby the speed of a falling object was independent of the weight of the object.

Table 1. Research motivators of actual physicists

M1: Incompleteness
M11: Inaccuracy of experiments
M12: Unidentified/undeveloped areas
M13: Unproven parts of the theory
M2: Discovery and Development
M21: Discovery of new data/phenomena
M22: Suggestion of a new theory
M23: Development of new materials
M24: Development of new experimental techniques/equipment
M3: Conflict
M31: Mismatches between theory and experiment (unexplained phenomena)
M32: Internal conflicts inside the theory

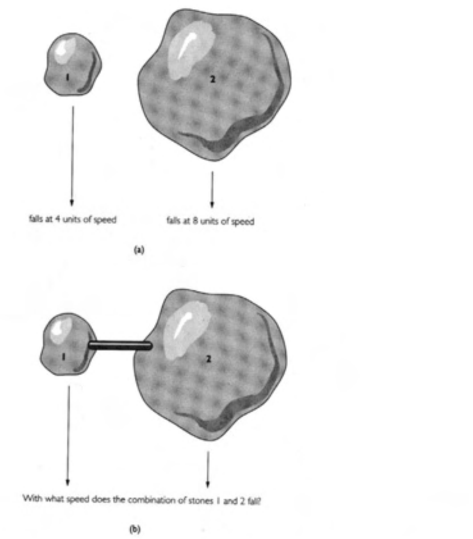


Figure 4. Galileo's thought experiment (quoted from Miller, 2000).

Einstein's special relativity is another example, as it was initiated by the following thought experiment which Einstein conducted at 16 years of age: what would be the consequences of running alongside a light wave? If a light wave is seen as being static (according to Galileo's relativity theory), then is it also a wave? (the electric and magnetic fields of a light wave should vary with time according to Maxwell's theory). Besides the given examples, many other instances can be seen in Miller's book (Miller, 2000), "Insight of Genius."

To encourage students to recognize conflict or inconsistency, the following tasks (Figure 5) can be used.

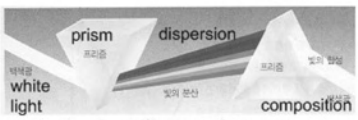
The level of synthesis depends on the number of concepts or ideas involved in constructing a structured system. In the history of science, we can see that scientific knowledge has developed by increasing the level of synthesis. For instance, electricity and magnetism were not connected with each other at first, however, after Ampere discovered a magnetic field around a wire in which an electric current was flowing, the two were interlinked. Later, by combining Ampere's law, Faraday's law, and Gauss's law into Maxwell's electromagnetic theory, electricity and magnetism were completely unified. Based on the fact that the speed of an electromagnetic wave derived from Maxwell's theory was the same as the speed of light, electromagnetic waves were regarded as being the same as light. Einstein's photoelectric effect then combined waves with particles.

To encourage synthetic thinking for students, Concept MapsTM (Novak & Gowin, 1984) which emphasize the meaningful relationship between concepts by connecting them using linking words can be useful (see Figure 6).

Combining natural phenomena with scientific concepts is also helpful for synthetic thinking as shown in Figure7.

Although many ideas or concepts are collected together, the total structure needs to be simple. Therefore, many scientists have mentioned simplicity as a category for a good theory or solution as follows:

[Task 1]
The following figure indicates that white light goes into the first prism and is dispersed into the various colors of light. Dispersed light becomes white light again by passing through the second prism.



Identify any incoherent aspects in the above figure and suggest new methods to disperse and composite light.

[Task 2]
Usually people think that the up and down of the image are interchanged by a plane mirror but that the right and left are not. Identify any incoherency between the above thinking and the following photo.

Figure 5. Activity for recognizing incoherency

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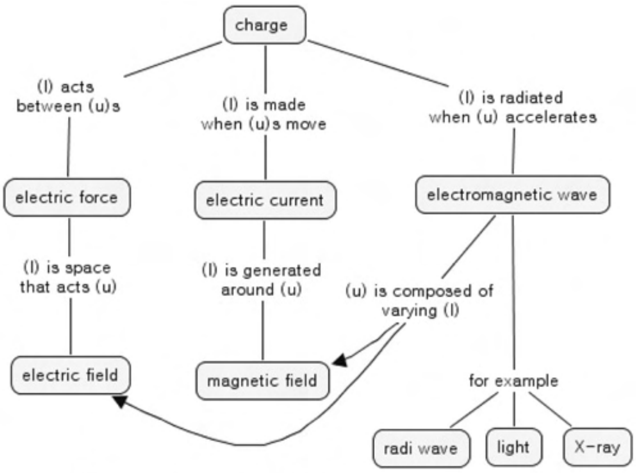
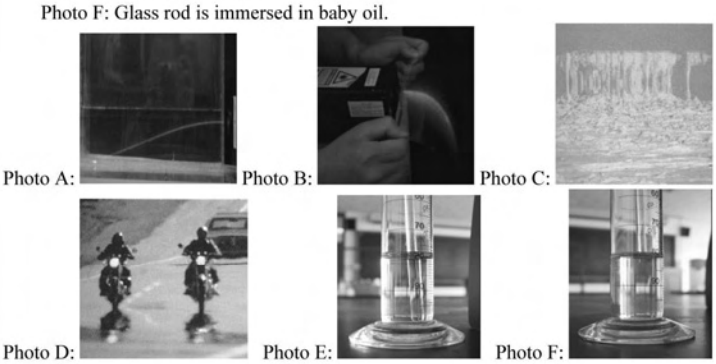


Figure 6. Concept map about electricity and magnetism.
Here, (u) means upper concept, and (l) means lower concept.

There are 6 photos as followings.

Photo A: Laser light is curved in the sugared water.
Photo B: Laser light is curved inside the OHP film.
Photo C: Mirage is generated in the Arctic region.
Photo D: Mirage is generated in hot asphalt road.
Photo E: Glass rod is immersed in water.
Photo F: Glass rod is immersed in baby oil.



Classify the above phenomena according to physics concepts involved in the phenomena or to criteria that you have invented. Then add as many other optical phenomena as possible that can be included in these categories.

Figure 7. Task for encouraging synthetic thinking

> *"⋯ he (Einstein) got the idea of connecting gravitation with the curvature of space. He was able to develop a mathematical scheme incorporating this idea. ⋯ The result of such a procedure is a theory of great simplicity and elegance in its basic ideas." (Dirac, 1979, p.92)*

Figure 8 shows the task for identifying simple regularities from complex data. Similarly, drawing simple tables, graphs, models, figural representations, or inventing symbols or mathematical representations are helpful for simplification of ideas or data.

3. Associational Thinking

New ideas cannot be derived from nothing. They are invented by connecting with extant ideas or borrowing other well-known ideas to understand new phenomena. Associational thinking plays an important role in discovering new ideas from other ideas. There are two types of associational thinking: similarity-based thinking and non-similarity-based thinking.

Analogy, metaphor, and abduction are involved in similarity-based thinking (Park, 2006). Mumford and Porter (1999) stress that analogical reasoning is one of

The following data are obtained by measuring position and velocity of a certain object. Identify important characteristics or hidden regularities, as many and as precisely as possible.

t	x	y
0	-1.2	0.2
0.05	-1.196	0.197
0.1	-1.185	0.189
0.15	-1.165	0.176
0.2	-1.138	0.157
0.25	-1.104	0.133
0.3	-1.062	0.104
0.35	-1.012	0.069
0.4	-0.954	0.029
0.45	-0.889	-0.017
0.5	-0.816	-0.067
0.55	-0.735	-0.124
0.6	-0.647	-0.185
0.65	-0.551	-0.252
0.7	-0.448	-0.325
0.75	-0.336	-0.402
0.8	-0.217	-0.486
0.85	-0.091	-0.574
0.9	0.044	-0.668
0.95	0.186	-0.767
1	0.335	-0.872

t	Vx	Vy	|V|
0	0	0	0
0.05	0.155	-0.106	0.187
0.1	0.308	-0.212	0.374
0.15	0.462	-0.32	0.562
0.2	0.615	-0.427	0.749
0.25	0.768	-0.535	0.936
0.3	0.922	-0.642	1.123
0.35	1.075	-0.75	1.31
0.4	1.228	-0.857	1.498
0.45	1.382	-0.964	1.685
0.5	1.535	-1.072	1.872
0.55	1.688	-1.179	2.059
0.6	1.842	-1.286	2.247
0.65	1.995	-1.394	2.434
0.7	2.149	-1.501	2.621
0.75	2.302	-1.608	2.808
0.8	2.456	-1.715	2.995
0.85	2.609	-1.823	3.183
0.9	2.762	-1.93	3.37
0.95	2.916	-2.037	3.557
1	3.069	-2.144	3.744

Figure 8. Task for encouraging simplification of data

New Phenomena (NP) has properties α, β, and γ.
Background Knowledge (BK) also has similar properties α', β', and γ'.
Then, the NP and BK share similar properties with each other.
And the BK has another property δ'.
Therefore, it is worth inferring that NP will also have property δ,
even though δ has not yet been confirmed.

Figure 9. The model of similarity-based reasoning

the key components of creative thought, and define it as a map of similarity between two or more phenomena. Holyoak and Thagard (1999) note that among the four distinguishable uses of scientific analogy - discovery, development, evaluation, and exposition - the most exciting use of it is when a new hypothesis is discovered. They suggest several typical examples of analogy, such as Darwin's animal and plant competition with human population growth, Maxwell's electromagnetic force with continuum mechanics, and Kekule's benzene-snake dream. While they studied the role of analogy in theory construction based on the historical cases, Dunbar (1997) observed the real work of scientists in molecular biology laboratories for a long period, and found that creative scientists used various analogies very frequently and creatively when formulating a new hypothesis.

Metaphors have also been emphasized as a fundamental tool in creative thinking. For instance, Miller (1996) describes how metaphors are used as a means to invent new knowledge in terms of established knowledge by great scientists such as Einstein, Fermi, Heisenberg, Maxwell, Salam, Weinberg, and Yukagwa.

Peirce (1955) argues that even though the process of creating a new hypothesis involves a psychological factor, it can also be viewed as a rational process. He says, "All the ideas of science come to it by the way of abduction. Abduction consists in studying facts and devising a theory to explain them" (Peirce, 1998, p. 205). Hanson (1961) also insists that guessing a new idea comes not from induction or deduction, but from abduction which "involves sensing ways in which the current situation is somehow similar (analogous) to other known situations and using this similarity as a source of hypotheses in the present situation" (quoted in Lawson, 1995, p.7).

Park (2006) observed, based on the analysis of students' processes for explaining new phenomena which conflicted with their prior predictions, that students used similarity-based reasoning between the new phenomena which needed to be explained and background knowledge which they already knew. Figure 9 indicates the steps involved in generating new ideas using similarity-based reasoning.

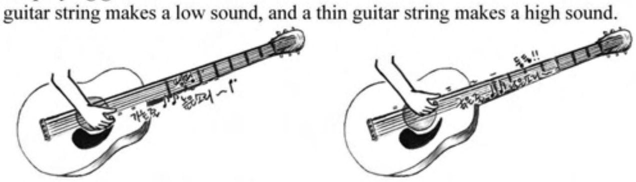
To encourage similarity-based reasoning in the context of physics, the following type of activity can be useful: "Find as many similar properties as possible between Faraday's Law and Hooks' Law." For this activity, the students can answer that (1) both try to go back to their original state, or (2) the two laws are about electromagnetic phenomena because the restoring force in Hook's law is generated by electric attraction between molecules. Figure 10 shows another activity for associational thinking based on similarity.

Not all types of associational thinking are based on similarity. Connecting or combining two ideas, even though they do not appear to share any similar properties with each other, can also lead to new ideas or novel products. For example, combining a wine glass with a liquid crystal thermometer can make a new wine glass indicating the proper temperature at which to drink wine, and "radio glasses" can be made by inserting a mini radio into a pair of ordinary eyeglasses with earphones connected to the glasses. In fact this type of thinking is a useful strategy for the invention of new items in commercial situations.

I. Suggesting a new hypothesis using similar situations.

We can make a beautiful sound by rubbing the brim of a wine cup. We can adjust the pitch of the sound by adjusting the amount of water. That is, a glass with more water makes a higher sound. Suggest a hypothesis which can explain this phenomenon using the following situation.

<Situation playing guitar>
A thick guitar string makes a low sound, and a thin guitar string makes a high sound.



II. Finding out and using similar situations

Electric wire is connected to a galvanometer and Jane is playing 'rope skipping' as in the following figure. In this case, we can observe that an electric current is generated.

Before suggesting a new hypothesis to explain the above phenomenon, remind yourself of the following similar situations:

(1) a similar situation which involves a 'rotating electric wire'
(2) a similar situation which involves 'generating electric current'
(3) a similar situation which involves 'playing rope skipping'
(4) a similar situation which involves a 'circular electric wire'
(5) any other similar situations which involve what you observed.

Figure 10. Activity for encouraging similarity-based reasoning

4. Others: originality, value, and elaboration

Originality is, in fact, the most important element of scientific creativity. Originality can be defined as 'something new which has not existed before', or 'a novel idea or product which others have not suggested or made before.' To evaluate one's originality, his/her idea or product should be compared to other's ideas or products. For instance, if a certain idea is suggested by only five people among one hundred people, then his/her idea can be viewed as 'original.' Of course, the '5%' standard is not absolute; for example, a lower standard (for instance, 3%) could be used for the selection of original ideas in a creativity contest, but a higher standard such as 10% could also be used in an ordinary practicing situation in school to encourage students' creativity.

If someone invents new powerful weapons, his/her activity cannot be regarded as a scientifically creative activity because it is not valuable for mankind.

> *"··· we shall define creative scientists as those whose work is considered high in both originality and value by other scientists in the same field." (Mansfield & Busse, 1981, p.3)*

Elaboration is another condition for good scientific creative activities. Many scientific ideas were not discovered in their completed form but instead were evolved and developed through successive articulation and refinement from the initial format of an idea. For instance, the initial atomic model suggested by Bohr in 1913 had various shortcomings that could not be solved at that time. But the initial model was articulated and refined by regarding the nucleus as being composed of protons and neutrons, by assuming that the nucleus moved around the center of mass, by modifying the circular orbits of the electrons into elliptical orbits in 1915, and by considering the relativistic effect of the mass of the moving electron. The reason why electrons did not radiate electromagnetic waves during movement in the specified orbits around the nucleus could be solved later when de Broglie's concept of a "matter wave" was invented in 1925.

5. Role of scientific knowledge and scientific inquiry in scientific creativity

> *"However, thinking alone will not lead to creative excellence, since creativity does not occur in a vacuum but in a particular field." (Cropley & Urban, 2000, p. 485-498).*

Scientific creativity can be actualized by linking the three previously mentioned types of thinking with concrete scientific knowledge. In fact, Weisberg (1986) stated that creative persons had more professional knowledge compared to less-creative persons, and Wolpert (1992) pointed out that scientific intuition leading to new discovery related not to common-sense experience but to highly specified knowledge (Wolpert, 1992, p. 64). These notes relate to Hempel's explanation of generating new scientific hypotheses. "Scientific (new) hypotheses are not *derived* from observed facts, but *invented* in order to account for them. ⋯ The inventive effort required in scientific research will benefit from a thorough familiarity with current knowledge in the field." (Hempel, 1965, p.15)

However, it is worth noting that background knowledge may obstruct the generation of new ideas. That is, background knowledge can narrow thinking and restrict it to the conventional (Cropley, 1999). This is also similar to the influence of the existing well-established paradigm on the evaluation of empirical data or views conflicting with it. Kuhn (1977) found that scientists often fail to reject existing paradigms when faced with anomalies or counter-instances. This is because background knowledge usually has a lot of supporting evidence and so it is not easily doubted. Therefore, even though background knowledge is important for the creation of new ideas, every inventor needs to go back to the novice state of mind.

> *"In the absence of appropriate personal properties such as 'openness to the spark of inspiration,' flexibility, or courage to try the new, great expertise can inhibit the production of novelty. In order to achieve effective surprise, experts need to be capable of seeing the contents of their field in a fresh light. Creative experts often show a freshness and openness that is more typical of beginners; this has been referred to as the 'novice effect.'" (Cropley, 1999, p. 516)*

In order to understand when creative thinking is necessary in the process of the scientific inquiry, we need to know the detailed processes of actual scientists' research procedures. Figure 11 indicates the actual physicists' scientific inquiry processes from the motives of research to the results of it (Park, Jang, and Kim, 2009).

Here, the important point is that scientific creativity should be actualized at a certain point in the process of scientific inquiry. For instance, when *obtaining and interpreting data*, scientific creativity can lead to the discovery of new features or hidden novel regularities. Or when *designing experiments to test scientific hypotheses*, scientists may invent new methods required to obtain important data through scientific creativity.

Operational Definition of the Elements of Scientific Creativity

Based on the above discussion about scientific creativity, we can now define each element of scientific creativity operationally as follows:

[Divergent Thinking]

Fluency – This means the number of ideas or products. All ideas or products can be counted to evaluate the fluency in ordinary creativity, but, in the case of scientific creativity, we select ideas or products which use or in-

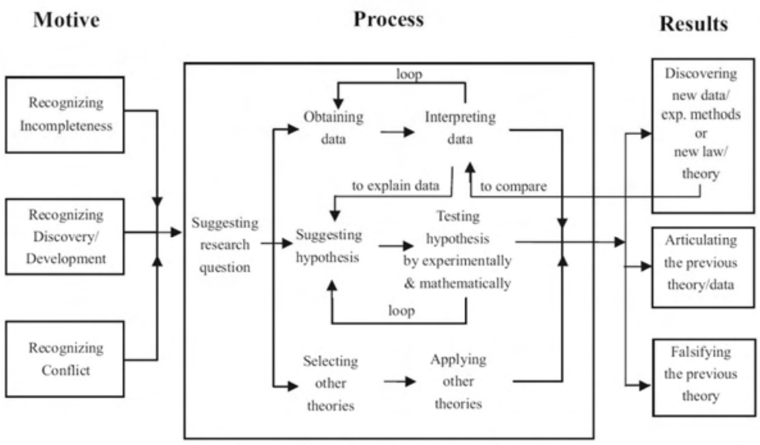


Figure 11. Scientific inquiry process

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clude scientific knowledge, which can be used in the process of scientific inquiry, or which have scientifically valid rationale.

Flexibility – This means the number of categories of ideas or products. To demonstrate flexibility, students need to suggest or make different types of ideas or products. The categorization can be determined by science concepts in scientific contexts.

Unusualness – This means different ideas or products compared to ordinary or conventional ones. For example, 'thinking reversely', 'changing basic assumptions or conditions', 'changing basic structure', 'assuming imaginary situations', or 'changing conventional scientific laws or definitions' can be regarded as unusual thinking. However, to be classed as scientific creativity, unusual thinking needs to have a scientific basis.

[Convergent Thinking]
Synthesis – This means the number of ideas or items involved in a structured or organized construction. For example, the number of concepts included in a concept map or the number of functions included in an invention corresponds to synthesis. It differs from fluency in the sense that synthesis means the number of structured ideas or items.

Coherency – This means that new ideas or products should have a scientific basis, logic, and consistency. If new ideas or products have logical conflicts, are against basic scientific laws or principles, or apply scientific knowledge in a wrong way, then these cannot be regarded as scientifically creative. In fact, the condition of 'coherency' appears conflicting with the condition of 'unusualness'. However, within the definition of scientific creativity, coherency is an essential necessary condition even for unusual thinking.

Simplicity – This means simplification through internal order or regularities. In a scientific context, finding out regularities from complex data, drawing up tables or graphs, inventing models or figural representations, or suggesting new names, symbols, or mathematical representations correspond to simplicity.

[Associational Thinking]
Similarity-based reasoning – This means a linkage between the idea or product and other ideas or products based on similarity between them. Similarity can be found in visible properties such as shape or color, internal characteristics such as density or electric conductivity, or scientific knowledge embedded in ideas or products, such as, 'there is energy conversion', or 'it makes a high sound when the mass increases'.

Linking without similarity – This means combination or connection between ideas or products and other ones even though there are no apparent similarities between or among them. New inventions usually use this type of thinking, for instance, the eye glass radio, laser pointer pen, or alarm calculator and so on. This associational thinking can contribute to synthesis if many connections are included in one structured product.

[Other Common Elements of Scientific Creativity]
Originality – This means new ideas or products that others do not suggest or make. The standard of originality cannot be absolute, but can be suggested by comparing with others' ideas or products. For example, if only five persons suggest an idea or make a product among one hundred persons, then the idea or product can be regarded as 'original'. Of course, this '5%' standard can be varied according to the situation. For instance, a '3%' standard can be applied to a creativity contest, but a '10%' standard can be used when teaching creativity in class to encourage students' activity.

Elaboration – This means that ideas or products should be detailed or precise. In the scientific context, drawing a detailed blueprint, suggesting concrete examples, or creating representations of ideas that include quantitative description can be regarded as elaborated activities.

Value – This means that new ideas or products should be helpful for human life, nature, or for solving specific problems, and also should satisfy an ethical standard.

Of course, the above 11 elements of scientific creativity cannot completely define scientific creativity; however, the above operational definition can be used to teach scientific creativity in a more concrete way.

For instance, instead of providing simple instructions for a creativity task, such as, 'suggest new ideas', 'invent your own product', or 'solve the problem creatively', we can give instructions in more detail if we use the opera-

Tom measures the electric current and brightness of a small electric bulb by varying the electric voltage from 1.5 V to 3 V.

Electric Voltage (V)	Electric Current (A)	Brightness (Lux)
1.5	0.198	45
2	0.232	170
3	0.283	752

Suggest new inquiry problems to be investigated: as many, as various, and as precisely as possible. When suggesting inquiry problems, use scientific knowledge, check whether there are any conflict aspects compared to existing scientific knowledge, and check that it is possible to conduct experiments for the suggested inquiry problems.

Figure 12. Task for suggesting new inquiry problems

Table 2. Brief scoring system for scientific creativity elements

Element	Score point
Fluency	Give 1 score point for each idea or product.
Flexibility	Give 2 score points for each category of ideas or products.
Unusualness	Add 2 score points for each example of unusual thinking such as reverse thinking, change of assumptions/conventional definition/basic structure, or use of imagination.
Synthesis	Give 1 score point for each idea or function involved in a structured system.
Coherence	Add 1 score point for each use of appropriate scientific knowledge, but -1 score point if ideas or products are logically invalid, lack scientific basis, or are scientifically wrong.
Simplicity	Add 1 score point for each use or invention of a simple representation such as a model, table, graph, figural representation, or symbol.
Similarity-based reasoning	Add 2 score points for each use or invention of an analogy or metaphor, or for each connection based on similarity.
Linking without similarity	Add 2 score points for each unexpected or improbable connection.
Originality	Add 10 score points for each idea or product meeting the 3% standard, 5 score points for 5% standard, or 2 score points for 10% standard.
Elaboration	Add 2 score points for each detailed or precise idea that includes a quantitative description, blueprint, or appropriate instances.
Value	Add 2 score points for each idea or product which is valuable for human life or the environment or for solving a specific problem effectively, but -10 score points for each inhuman or unethical idea or product.

tional definition of scientific creativity elements. In Figure 2, we can infer that the task requires fluency, flexibility, and originality, whereas the task in Figure 12 requires fluency, flexibility, elaboration, and coherence.

In addition, the operational definition of scientific creativity elements can be used to evaluate scientific creativity. For instance, as mentioned earlier, fluency can be evaluated by counting the number of ideas. In this case, we count only scientifically valid ideas, and then coherence is evaluated simultaneously. If a certain idea contains more concrete examples or detailed quantitative description, then it also increments the elaboration score. Similarly, for originality, the evaluator can give 5 points if the student's idea or product meets the '5% standard', 10 points if it meets the '3% standard', or 2 points if it meets the '10% standard'. Therefore, the following Table 2 contains a brief guide for evaluating scientific creativity. Even though this brief scoring system should be revised according to the task characteristics, it can give basic guidance for evaluating scientific creativity.

Steps for Learning Scientific Creativity

To teach scientific creativity, Park, Park, & Lee (2008) suggested a learning model consisting of three steps: spontaneous activity, guides for creative thinking, and activity again (see Figure 13).

In the first step (spontaneous activity), students are provided with a task to be solved, such as 'revise the presented ordinary electroscope for more diverse usage', 'suggest various new scientific hypotheses to explain the observed phenomena', or 'suggest new and interesting situations which may show unusual phenomena', as shown in Figure 14.

In the first step, students solve the tasks by themselves, that is, there are no hints, guides, or aids to help in the students' solving activity. Therefore, some students can show high levels of creativity by solving the tasks successfully, while many others may solve the tasks by using common sense or in conventional ways, and also, some students may confront difficulties in solving the tasks.

Step 1: Activity	–	Students conduct the given task spontaneously
↓		
Step 2: Guides	–	Guides are given to help students' creative activity
↓		
Step 3: Activity Again	–	Other activities are provided to give students opportunities to use guides in other situations

Figure 13. AGA^2 model for scientific creativity activity

A ping-pong ball is attached to a spring and inserted into a transparent bottle with water. If it is placed on the rotating table, then you can see that the ball moves in the inward direction which is different from the usual situation.

1. Likewise, find any other interesting situations which can show unusual results.
2. Explain the results: why do such unusual results happen?

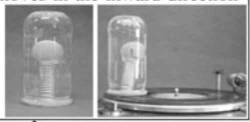


Figure 14. Activity in the first step of AGA^2 model

Therefore, in the second step, we provided actual guides which could encourage students' creative activity. In Figure 15, four basic guides are provided to help students suggest new unusual situations. Of course, these guides are not general rules for all types of scientific creativity but may differ according to the tasks. However, the basic concept of the guides is closely related to the three types of creativity thinking in MSC. For instance, the three guides provided in Figure 15 are basically designed to encourage 'unusualness' which is one component of divergent thinking. That is, in order to encourage students to think unusually, they guide the students to change the ordinary structure or the assumed conditions, and to think reversely.

The final step is to apply the guides in the second step to other new situations. In Figure 16, students are encouraged to apply the guides to finding unusual phenomena using a usual electroscope.

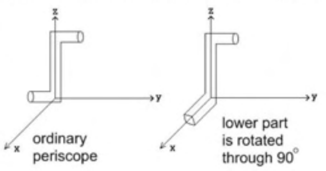
Students' Responses to the Worksheets for Scientific Creativity

Recently, Park, Park, and Lee (2008) developed about 30 learning materials for scientific creativity based on the AGA2 model. These materials were classified into three categories: thinking creatively in a scientific context, conducting scientific inquiry creatively, and understanding/applying scientific knowledge in creative ways.

To find unusual situations and to explain them, the following guides can help you.

Guide 1: You can change the basic structure. For instance, you can rotate the lower part of periscope as in the figure:

(1) Describe and explain what you observe using a 'strange periscope'.
(2) Find any other unusual phenomena by changing the basic structure of an ordinary periscope.



Guide 2: Now, you can also change the assumed conditions involved in the usual situation. For instance, when calculating the falling speed, we usually assume that there is no air resistance. However, you can also think about the falling object in the air.

(1) Predict what will happen when air resistance acts on falling objects.
(2) Find any other unusual phenomena by changing the assumed conditions for the falling object.

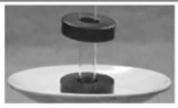
Guide 4: Finally, reverse thinking can also help you find unusual phenomena. For instance, usually a convex lens made from glass is placed in the air. However, you can think about a convex lens formed by air inside the glass.
(1) Describe and explain what you observe using this 'air convex lens'.
(2) Find any other unusual phenomena by applying reverse thinking to an ordinary convex lens.

Figure 15. Activity in the second step of AGA^2 model

Now, find any unusual situations involving the usual electroscope by applying the above 3 guidelines.

Figure 16. Activity in the third step of AGA^2 model

Two ring magnets are put onto the plastic rod as shown in the photo. Because of the repulsive force between the two magnets, the upper magnet is floating in the air.



After observing the phenomena, suggest various problems (questions) whose investigation would be valuable, as many and precisely as possible.

Figure 17. Problem situation used in activity

In the 'Center for the gifted in Science' in my university, I have applied the learning materials to the teaching of the gifted students for several years and analyzed their responses to obtain information about whether they enjoyed the scientific creativity activities, whether there were any difficulties in conducting the activities, whether the guides provided in the second step were effective for their creative activities, and so on.

Now, many data have accumulated and other research colleagues with me have analyzed the data in different ways, but not all the analysis is yet completed. Therefore, here, I would like to briefly show some examples of the results. It is worth mentioning that some examples of the results are undergoing more detailed analysis.

(1) The learning material was used for nine students (7~8 grade, 13~14 years old) in the 'Center for the Gifted in Science' (Park and Jee, 2010). The second step and the third step activities were presented after completing the first step activity. It took about three hours to complete all three steps. From the analysis of students' responses using the 5 point Likert scale (5 points means highly agree, 3 means neutral response, 1 means highly disagree) questionnaire after the activity, students answered that even though the activities were not easy for them (the average response was 2.4), they were interesting to them (4.0), they were helpful for them in understanding scientific knowledge (3.6), and they could improve their creative thinking (4.0). As a result, they answered that they wanted to conduct this kind of activity in the future (4.3).

(2) In the study by Park (unpublished), fourteen students from grades 7 and 8 were asked to generate various new scientific inquiry problems which would be valuable to investigate (Figure 17 is the first step of the learning activities for generating scientific inquiry problems).
In this study, I analyzed the number and variety of inquiry problems that were generated before and after using the guides in the second step.

The results show that in the first step, the total number of inquiry problems (IPs) spontaneously suggested by students was 86 (average 6.1 per person). However, in the second step, in which guides for creative thinking were provided, the students suggested 78 additional IPs (average 5.3 per person). This means that the number of IPs suggested by the students increased by 91% (= 78 ÷ 86 x 100). Comparing the total number of IPs with the initial number of IPs before the guides were provided in the second step, the increase is statistically significant ($t = 7.4$, $p < 0.01$). This means that the guides provided in the second step improved students' fluency (the number of ideas) which was a feature of divergent thinking.

We also compared IP types for each student before and after the guides to check whether the number of IP types is increased by the guides. As a result, I found that the total number of IP types was on average 2.5 in the first step, but it increased to 3.6 in the second step. That is, the number of IP types increased by 44% (= (3.6 - 2.5) ÷ 2.5 x 100), and the difference in the number of IP types between the first step and the second step was statistically significant ($t = 3.4$, $p < 0.01$). This means that the guides in the second step improved students' flexibility (variety of ideas), which was also a feature of divergent thinking.

Conclusion

In this article, based on the assumption that scientific creativity may have different features compared to creativity in other areas such as literature or art and so on, the model of scientific creativity (MSC) is suggested. Of course, to understand scientific creativity more completely, the role of personal characteristics such as openness, autonomy, self-confidence and so on, the role of social, environmental, or educational supports, and/or the role of intrinsic/extrinsic motivation should be discussed more widely. Therefore, in future research, other various and important aspects can be added to the MSC suggested in this article.

In addition, theoretical models should be verified and we should ensure that they are applicable in various contexts. To do this, many concrete scientific creativity activities were also developed and applied for gifted students in science. Here, I showed some examples of results showing the students' responses to the developed activities. In the near future, I hope that more detailed results about the effects of the developed activities in terms of improving the students' scientific creativity will be presented.

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E·A·S·E

- Regional Special Session
- Date: Friday, October 28, 2011
- Time: 10:20 ~ 11:00
- Room: #2 (1F)
- Chair: Jinwoong Song (Seoul National University, Korea)

1.

COMPARATIVE SURVEY OF SCIENCE CULTURE INDICATORS ON REGIONAL LEVEL IN EAST ASIA

Jinwoong Song
Seoul National University, Korea

Masakata Ogawa
Tokyo University of Science, Japan

Chiaju Liu
National Kaohsiung Normal University, Taiwan

Enshan Liu
Beijing Normal University, China Mainland

May Hung May Cheng
Oxford University, UK

Young-Shin Park
Chosun University, Korea

Since the practice of science education is very much dependent on its social and cultural backgrounds, each region of EASE would have a different set of the strength and weakness of science education even within the regions of East Asia. In this Symposium, together with a general overview of science education in the regions, presenters from EASE regions (i.e. China Mainland, Hong Kong, Japan, Korea, and Taiwan), based on their personal experience and expertise, will explain at least three points of strength and of weakness of their own regions' science education with some supporting data and information. Through these presentations, it is expected that we could see how much the strength and the weakness are shared together or are different from one another and thus that we would better understand the practice of science education in the regions. The similarities of the strength and the weakness would be the common grounds for us to work together to tackle the issues, while the differences would be the starting points for each of our regions to seek the unique ways to improve the practice of science education in each region's specific context, but still with lessons from other regions' situations and experience. We are hoping that this Symposium would provide us an example of our collective efforts for the communication and sharing of the knowledge and wisdom of the science education community in East Asia.

E·A·S·E

- Contributed Workshop 8
- Date: Friday, October 28, 2011
- Time: 10:20 ~ 11:00
- Room: #3 (1F)
- Chair: Jeonghee Nam (Pusan National University, Korea)

1.

USING MICROBIAL FUEL CELLS FOR THE INTEGRATED TEACHING OF THE NATURAL SCIENCES

Timothy T. M. Tan*, Peter P. F. Lee, Yew Jin Lee
National Institute of Education, Singapore
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Microbial Fuel Cells (MFCs) are a class of fuel-cells that employ microbes to generate electricity. The technology shows potential in niche areas such as the self-powered treatment of wastewater and other novel uses. We believe that the MFC can be used as an exciting school laboratory-based activity to engage students and synergistically cover and extend upon curriculum topics in biology, chemistry and physics. The use of commercially available MFC kits, as well as improvised MFCs designed and constructed by students will be introduced in this workshop, together with ideas for lesson activities and project work that teach content and conceptual knowledge, process and investigative skills in science, and/or foster scientific inquiry. These activities would be suitable for lower secondary (middle school) to junior college (senior high school) levels. The inter-disciplinary material would be useful for general science education at the lower levels, as well as to underscore the inter-relationships between the disciplines for students at all levels.

- Contributed Workshop 9
- Date: Friday, October 28, 2011
- Time: 10:20 ~ 11:00
- Room: #4 (2F)
- Chair: Yew-Jin Lee (Nanyang Technological University, Singapore)

2.

PROPOSE OF NEW EXPERIMENTS ABOUT MOTION OF GAS MOLECULES THROUGH ANALYSIS OF EXPERIMENTAL ERRORS

Dae Hong Jeong*, Jongho Baek
Seoul National University, Korea
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In this presentation, we propose new experiments about motion of gas molecules. We designed experiment by analysis of experimental errors using theoretical investigation. First experiment is inquiry experiment that compares molecular diffusion with effusion. Using this experiment, pre-service teachers could change their concept about diffusion. Second experiment is improved experiment on diffusion rate of gases. Original experiment introduced in high school chemistry textbooks, however, experimental condition is not good for collecting data. So we propose detailed experimental condition through theoretical investigation.

- Contributed Workshop 10
- Date: Friday, October 28, 2011
- Time: 10:20 ~ 11:00
- Room: #5 (2F)
- Chair: Sungmin Im (Daegu University, Korea)

3.

MEASURING CHANGES IN BALANCE OF OXYGEN AND CARBON DIOXIDE IN THE AIR: COMBUSTION EXPERIMENT USING GAS DETECTOR TUBES

Moonjung Han*
Sookmyung Girl's High School, Korea
✉ *moonjhan@chol.com*

GASTEC Co. is a company which devises easy-to-use, quick-measuring, and very sensitive gas detector tubes. The workshop starts with a question: "How does combustion affect the balance of oxygen and carbon dioxide inside of a 1-liter pop bottle?" Using Oxygen detector tube and Carbon Dioxide detector tube, we measure the levels of each gas before and after combustion to better understand their relationship to one.

- Science Demonstration 3-A
- Date: Friday, October 28, 2011
- Time: 11:00 ~ 12:00
- Room: Main Room

1. SD3-A1

OBSERVING AN ELECTRIC FIELD AND LIGHTENING WITH STATIC ELECTRICITY

Hyung-do Park*
Hanam Middle School, Korea
✉ *muru2000@naver.com*

Although it is easy to see a magnetic field with steel powder and magnets, it is difficult to see an electric field in reality. As we can lighten a bulb by flowing electric currents, we can lighten a bulb using static electricity. However, because static electricity has high voltage, neon tube lamps and fluorescent lamps are needed. In this demonstration, you will observe an electric flux with various devices to generate static electricity and check the existence of static electricity through the demonstration using a neon tube lamp and a fluorescent lamp.

2. SD3-A2

MAKING A ELECTROSTATIC MOTOR

Hyeon Cheol Yu*
Gwangju Electronic Technical High School, Korea
✉ *titan00@hanmail.net*

There are not many ideas how to use static electricity in daily life. That's why we are going to make a electrostatic motor, different from a motor using an electromagnetic force, with simple materials such as a paper cup and a small sized Van de Graaff electrostatic generator. We want you to increase the interest in useful electricity and understand an electrostatic force after observing how to operate the motor.

3. SD3-A3

CONDENSER (MICROPHONES MADE OF ALUMINUM FOIL)

Euntai Wi*
Wol-gok Middle School, Korea
✉ *eunt629@naver.com*

We can make a condenser - which stores static electricity - with aluminum foil, something that we usually use in our daily lives. We can make the condenser by using two pieces of aluminum foil and OHP film, making sure that it stores static electricity. After linking the aluminum foil condenser to a speaker, we can try to use it as a microphone. This will show that simply-made condensers can be used as microphones. Students should be able to easily understand the principles of storing static electricity and making microphones.

4. SD3-A4

SOUND FILTERS BY USING CONDENSER OR COIL & SPEAKER DISASSEMBLY

Jin Ho Lee*
Gwangju Girl's High School, Korea
✉ *sanmak28@empal.com*

We are to get a low-noise sound. We would like to select only the bass or treble. ow can we do in an electrical circuit? Now we see the speaker disassembly.

1. The characteristics of the capacitative circuit: In a circuit containing a capacitative element only, we know the quantity Xc = 1/wC, called the capacitative reactance of the capacitor at the frequency. As you know, the SI unit of Xc is the ohm, just as for resistance R. The higher the frequency of current, because Xc is less, we expect to get loud.

2. The characteristics of the inductive circuit: In a circuit containing an inductive element only, we know the quantity XL=wL, called the inductive reactance of the inductor at the frequency. The SI unit of XL is also the ohm, just as for capacitative reactance Xc. The lower the frequency of current, because XL is less, we expect to get loud.

With characteristics of capacitative circuit or inductive circuit, we make the Noise Reduction Circuit. You see the results of various combination of the circuits in experiment. Students are intended to get creative thinking as well as the knowledge of electrical circuits through this experiment.

5. SD3-A5

MIRROR REFLECTION

Jihoon Kim*
Gwangju Science High School, Korea
✉ *magilla@naver.com*

In these three demonstration, when you raises your right hand, why does your left hand appear to go up in the mirror?
Demo 1 : XYZ axes in the mirror
Demo 2 : How we can we endure the flare of candle?
Demo 3 : Mirror writing

6. SD3-A6

INTERESTING REFLECTION

Jongwon Park
Chonnam National University
Hwoe-gwan Yang*
Gwangju Science High School, Korea
✉ *01086081307@nate.com*

Following three physics demonstration will be shown : (1)endoscope made by plastic optical fiber, (2) mirror blocks which can rotate image in various direction, (3) strange periscope

7. SD3-A7

PINHOLE CAMERA

HanSu Lee*
CheomDan Middle School, Korea
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Although the way we observe the images of an object using a pinhole camera is wildly known, the way we take pictures is very difficult. However, it is easier to take a pinhole camera picture using a polaroid film. In this demonstration, we are going to make a simple pinhole camera and show how to take a photo with a polaroid film. Then you will see the most uncomplicated camera in the world and the result.

8. SD3-A8

HOW TO SHOW RISING CARBON DIOXIDE BUBBLE DISSOLVED IN A LONG TUBE OF WATER

Fujio Hiramatsu*
Attached Elementary School of Tsukuba University, Japan
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One of the important units in Grade 6 elementary science in Japan is “the nature of the solution.” Students have learned that solids and liquids are soluble in water in earlier grades. In this unit, the students come to be challenged about whether or not gas can be dissolved in water. Students are expected to gain the new idea and to adapt it when they observe a breathing fish or a soda drink. This presentation focuses on the experiment of carbon dioxide gas dissolution in water. Typically, a gas bottle with lime water covered with a balloon is shaken, and based on the decreased volume of carbon dioxide and the white turbidity of the lime water students are to infer that the gas dissolved in the lime water. An innovative experimental method was developed using a long glass tube and will be introduced in this session. If the volume of rising carbon dioxide bubble in the tube is observed to be smaller then students can more readily infer the concept. Many science education practitioners have struggled to develop this experiment using a longer tube or a smaller bubble but without success. I shall introduce this method in an experimental demonstration.

- **Science Demonstration 3-B**
- **Date: Friday, October 28, 2011**
- **Time: 11:00 ~ 12:00**
- **Room: Lobby**

9. SD3-B1

SEVERAL DEMONSTRATIONS ABOUT TOTAL INTERNAL REFLECTION

Kwangsik Kim*
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Total internal reflection is an optical phenomenon that happens when a ray of light strikes a medium boundary at an angle larger than a particular critical angle with respect to the normal to the surface. We consider light coming from a dense medium into a less dense medium. So let me show you several demonstrations about total internal reflection ; (1) J. Tyndall's experiment, (2) observing ray of light in optical fiber, glass tube, plastic ruler(30cm), OHP film.

10. SD3-B2

OPTICAL COMMUNICATION

Seung-Hee Choi*
Gwangju Science High School, Korea
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Optical communication is a method of communicating information using optical fiber cable instead of previous copper cable. A method like this is used for communication channel for the Internet. On this experiment, sending vocal signal through the light can be done. Although the experiment is not an actual optical communication, but it is similar to an optical communication. The experiment will be performed sending voice through laser beam, and transferring music by LED(light emitting diode). One can check with eyes that sound is vibration by light. Also, one can sense with own eyes and ears the result of voice and music delivered by light and being played on a speaker.

11. SD3-B3

INFRARED REMOTE CONTROL

Sang Mi Kang*
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There are many electronics working by remote control. To send information, the remote control uses infrared rays, which is invisible. In this demonstration, you can see infrared rays using a simple device and hear it converted into sound. In addition, we are going to show the differences in the diverse signals from the buttons of remote control to send various information.

12. SD3-B4

SYNTHESIS AND DEGRADATION OF LIGHT

Dong Sik Kim*
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Synthesis and degradation of light is very interesting topic for students. However in actually experiment, it is difficult. In this experiment, using a computer and a projector, simply to try synthetic light and by using color filter Simply decompose the light.

- Oral Presentation 5-A
- Date: Friday, October 28, 2011
- Time: 09:00 ~ 10:00
- Room: #1 (1F)
- Chair: Tsun-hui Shih (National Taipei University of Education, Taiwan)

1. O5-A1

A STUDY OF THE LEARNING OUTCOME ON THE TEACHING OF BIODIVERSITY IN THE ZOO FOR FIFTH GRADE STUDENTS

Tsun-hui Shih*, Ching-san Lai
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The purpose of this study is to evaluate the influences of this instruction on the fifth grade students' concept of biodiversity and their attitudes toward biodiversity conservation, through the teaching activities of biodiversity in the zoo. A quasi-experimental design was used in this study. The research tools used by this study include "the Learning Achievement Survey of Biodiversity" and "the Scale of the Attitude toward Biodiversity Conservation" and the pre-test/post-test questionnaire was used in this study to assess the outcome effects. The main findings of this study were as follows: (1) with the involvement of experimental courses, the students' biodiversity concepts are greatly improved, (2) with the involvement of experimental courses, the students' attitudes toward biodiversity conservation are greatly improved.

2. O5-A2

STUDY ON THE CHEMISTRY EPISTEMIC STYLE OF HIGH SCHOOL STUDENTS

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Chemistry epistemic style refers to the way by which individuals reflect actively toward objective things from the chemical perspective. This is the thinking pattern that students tend to adopt when thinking about or handling chemical problems. Likewise, this is the measure or pattern of information processing adopted by students when comprehending or solving chemical problems. Chemistry epistemic style is characterized by the features of stability, content attribute-based, educability, and elusiveness. Chemistry epistemic style includes two components, namely, epistemic perspective and epistemic style category. The organic integration and unified action of epistemic perspective and epistemic style category results in the epistemic style that favors certain epistemic field. Another outcome is the formation and development of epistemic style which is related to the function and value of epistemic development of core knowledge. This study has surveyed the degree of identification of chemistry teachers and researchers on the configuration model of chemistry epistemic style through questionnaires. According to the survey results from 4889 chemistry teachers and 22 chemistry researchers, both chemistry teachers and researchers agree on a particular level with regard to the epistemic style proposed by this study. Through analysis on construct validity of measurement tools developed based on the configuration model of epistemic style, the researcher checked the rationality of the configuration model of chemistry epistemic style. The result of statistic analysis on survey data of chemistry epistemic style of 764 high school students from different regions and schools with different levels and stages of learning indicates that the chemistry epistemic style built by this study conforms to the configuration of chemistry epistemic style of high school students. Based on the configuration model of epistemic style, this study has analyzed the epistemic styles from the four perspectives of epistemic topic, epistemic style, epistemic ability, and function and values of epistemic development on chemical knowledge in the four epistemic fields of organic chemicals, inorganic substances, chemical reaction, and electrolyte solution. Subsequently, the configuration model of chemistry epistemic styles and hierarchical model of epistemic development for the above four epistemic fields are built. This study has analyzed the chemistry epistemic styles reflected by teaching books at different stages on the above four epistemic fields through the textual analysis method. Moreover, the study has provided theoretical basis for the model of epistemic style and hierarchical model of epistemic development for the four epistemic fields mentioned above. Through analysis on construct validity of measurement tools which are developed based on the configuration model of epistemic style, the researcher investigated the rationality of the configuration model of chemistry epistemic style. The result of statistic analysis on survey data of chemistry epistemic style of 764 high school students from different regions and schools with different levels and stages of learning indicates that the chemistry epistemic style built by this study conforms to the configuration of chemistry epistemic style of high school students. This empirical study indicates that both the pedagogy and books used in teaching affect the formation and development of chemistry epistemic style of high school students. However, when the teaching book does not describe clearly the chemistry epistemic style, teaching will be an important factor that can influence the epistemic style development of high school students. The thinking style (cognition style) of students is not relevant to the chemistry epistemic style.

3. O5-A3

INCULCATION OF ACTION RESEARCH CULTURE AMONG SCIENCE AND TECHNOLOGY UNIVERSITY'S LECTURERS

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This paper discussed how National University of Malaysia (UKM), propagated and establish an action research culture among its science and technology lecturers. Having a humble beginning of inviting lecturers to work collaboratively with science education lecturers to carry out research on improving the teaching and learning at the science faculty, the university took as its responsibility to improve the quality of education in all faculties, Professional Development in service training course were held and incentives and funding were provided for

the research includes the recognition on the study and its publication. Special workshops were also held by invited action researchers from Britain and Australia to strengthen the knowledge and development of the skills in embarking active research. An annual seminar is held to encourage lecturers to share their action research findings. The papers presented were refereed by internal experts before publishing in a special SCOPUS proceeding. The Deputy Vice-Chancellor headed the setting up of special communities to coordinate the work at the faculty and university level to over sear the running of the research. Thus a new beginning was made at the university level in inculcating the research culture on teaching and learning. The paper reported some of the strategies used to overcome the difficulties, resistance or passions to embark on such study. A model for establishing this culture is then proposed based on a number of stages involved in the inculcation of the research culture that was carried out.

- Oral Presentation 5-B
- Date: Friday, October 28, 2011
- Time: 09:00 ~ 10:00
- Room: #2 (1F)
- Chair: Hye-Gyoung Yoon (Chuncheon National University of Education, Korea)

4. O5-B1

A CASE OF PRE-SERVICE TEACHERS' EFFORTS TO IMPROVE THEIR SCIENCE INQUIRY TEACHING: FOCUSING ON THE COMMENTS OF EXPERTS AND REFLECTIVE ACTIVITIES

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To improve teachers' knowledge and skills of inquiry teaching, it is critical that teachers have an opportunity to reflect on context-specific feedbacks from experts. This study attempted to provide pre-service teachers with opportunities to practice microteaching and reflect on teacher educators' feedbacks on their practice. 4th year university students in teacher education program participated in planning, teaching, reflecting, and revising their practice through collaborative discussion and reflection. They designed and taught lessons which they thought were the most suitable for inquiry teaching. Their teaching practice was video recorded and reviewed by 4 teacher educators in different places for written feedback (Korea, Canada, and US). The teacher educators shared their feedbacks with the pre-service teachers to discuss and revise the original teaching plans and practice. Throughout the process, pre-service teachers discussed their own practice based on the feedbacks and wrote their reflection. Their discussions were audio-recorded and written reflection was collected for data analysis. This study focused on the following questions; (a) what are the characteristics of inquiry teaching in pre-service teachers' understanding? (b) How do they reflect on and respond to teacher educators' feedback? and (c) what are the changes in their understandings of inquiry? In the findings, pre-service teachers showed two paralleled foci on inquiry process and content. They agreed on most of the feedbacks but also experienced conflicts with them. They went through discussion and reflection to make decisions and action on their second teaching, which led them into positive and satisfactory changes in inquiry teaching. The study suggests that looking into interrelationships among reflection, action, and expert feedback can be a meaningful approach to understanding and developing teachers' knowledge and action and further help become transformative practitioner in inquiry teaching practice.

5. O5-B2

A PRELIMINARY CASE STUDY OF A ONE-YEAR TEACHING MENTORING: PROGRAM AND PROFESSIONAL GROWTH IN ELEMENTARY SCIENCE TEACHING

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In Taiwan, a major approach for enhancing teaching competency for teachers who are new to science teaching is to establish a partnership between beginning (partner teacher) and experiencing science teacher (mentoring teacher). However, the best practices of building up this relationship with mutual trust, support, and growth have not well established. Thus, the main purpose of this study was to explore what beginning science teacher needs in teaching science and to developed a feasible model of teaching mentoring practice in elementary science teaching. The methodology used in this study is the action research. One teacher who did not have previous science teaching experience and one experiencing science teacher worked together in this study. The action research lasted for one year. During the study, mentoring and beginning teachers steady focus on utilizing teaching resources, such as: time, manpower, materials, administrative assistances, etc. to nurture the teaching mentoring program. The research modified a teaching mentoring model proposed by the Ministry of Education, Taiwan. In the process, partners formulated solutions from common problems to sophisticated PCK, through collaborative lesson planning, teaching observation, micro-teaching, discussion and reflection on teaching belief. The study found that, after the teaching mentoring program, the beginning science teacher was satisfied for the partnership promoted her self-growth and strengthened teaching. And she was also glad to work with the mentoring teacher. Moreover, for her, the textbook was no longer just a textbook; it was an exciting vehicle of conveying inspiration to students. The teaching mentoring program in this study was regarded by this beginning science teacher as a delightful and worthwhile experience as well as one valuable approach of promoting professional growth for beginning science teachers.

6. O5-B3

BELIEFS OF EXCELLENT SCIENCE TEACHERS

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The research study is mainly descriptive and qualitative. This research is a preliminary model/theory building based on Pandit's process of building grounded theory from case studies. The purpose of this study was to investigate the beliefs of excellent science teachers. It involved science teachers who are consistent recipient of the Teaching Excellence Award in Biology, Chemistry and Physics from three participating schools, the Far Eastern University, the Central Luzon State University and the La Consolacion College Manila. They were selected using the purposive sampling. The multiple method of collecting data was used in the study namely interview, classroom observation, and students' comments from their evaluation. These modes of collection (document, interview, observation) provide important data needed in this study. All data collected were analyzed using Pandit's grounded theory methodology and the constant comparison method. "Beliefs of Excellent Science Teachers on Teaching, Learning and Role of Teachers" was the central concern that emerged. The results revealed the following beliefs of excellent science teachers: 1) Teaching should promote meaningful learning by allowing the students to experience authentic learning and by contextualizing teaching; 2) Teaching should be student centered by using adaptive teaching, practicing flexibility and keeping students' interest; 3) Teaching should facilitate learning by using instructional materials; 4) There is learning when students develop science pedagogic knowledge through promoting understanding and developing knowledge of the subject matter; 5) There is learning when students develop the necessary skill; 6) Prior knowledge transfers learning; 7) Teachers should develop lifelong learners as part of their commitment to students; and 8) Teachers should continue to develop professionally as their commitment to their profession which could be achieved through colleagues and by continuing education.

- Oral Presentation 5-C
- Date: Friday, October 28, 2011
- Time: 09:00 ~ 10:00
- Room: #3 (1F)
- Chair: Yau-yuen Yeung (HKIED, Hong Kong)

7. O5-C1

SCHOOL-BASED SUPPORT FOR IMMERSING DIGITAL TECHNOLOGY INTO THE INQUIRY-BASED PROJECT LEARNING OF SCIENCE IN A PRIMARY SCHOOL

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Inquiry-based learning and project learning are often considered capable of increasing students' interest of learning science, developing their scientific investigation and thinking skills, and cultivating their ability for independent and collaborative learning. On the other hand, digital technology can further enhance the learning effectiveness of those pedagogies. However, there still lacks sufficient research findings and implementation experience on incorporating digital technologies into the inquiry-based project learning in primary schools. Therefore, the present work of a two-year project provides some intensive school-based support to a Hong Kong primary school for that aim through (i) workshops for teachers' professional development; (ii) lesson study consisting of collaborative design of lessons and post-lesson conference for reflection and refinement of teaching; (iii) test-bed; and (iv) evaluation of students' learning through questionnaire survey, subject matter test, interviews and lesson observation. Students and General Studies teachers of Grade 3-6 in this school participate in this project. A total of 4 topics were selected to adopt the inquiry-based project learning approach in a digital technology rich environment. They are living in Hong Kong, sound and light, electricity and simple mechanics, respectively for grade 3-6. For the electricity theme, four inquiry activities were conducted by students in Grade 5 to study closed circuit, conductor, fruit cells, and generation of electricity by magnet. Each activity lasted for 80 minutes. A total of 4 General Studies teachers and 124 students were involved. A preliminary analysis of the questionnaire and knowledge test of Grade 5 indicates that students (i) gain significant improvement in their conceptual understandings of electricity；(ii) acquire the basic skills of using digital technology in inquiry activities; (iii) are confident to use digital technology in their learning; (iv) perceive that both inquiry-based project learning and digital technologies can increase their interest in learning. Lesson observations reveal that teachers still lack the abilities to handle the inconsistent data collected by students. It is suggested that digital technology can be appropriately adopted in the inquiry-based project learning in primary science, but teachers still need more experience to doing inquiry so as to get deeper understanding of the nature of inquiry itself, which is helpful for dealing with the complicated situations of organizing inquiry-based project learning.

8. O5-C2

A PRELIMINARY CASE STUDY ON SCIENCE TEACHERS' DIFFICULTIES OF BECOMING AN EDUCATIONAL GAME DEVELOPER

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It is frequently found the teacher-student interaction is one-way, because the limitation of environment and other related factors, therefore students do not have many opportunities to learn how to think that is necessary in scientific inquiry. With updating development of modern technology, one of the solutions is adopting computer educational game as the learning tool. In the education computer game learning, science educators may provide learning environments and experiences for students to foster their scientific literacy more effectively and without the limitation of time and space. Many literatures

have provided strategies and effectiveness results about this. However, the lack of an adequate authoring tool and the lack of science teachers to provide sufficient courseware have inhibited the growth of this innovative learning approach. Recently, our research group has successfully developed an authoring tool for computer educational game. To train science teachers to be good courseware developers has become the immediate task. Unfortunately, existing teacher training programs as well as previous studies did not provide enough training or information to transfer science teachers into good courseware developers. Thus, this study aims to formulate science teachers' difficulties while they start to develop an educational game for students' science learning. The research methods use in this study was action research. During a four-month training process, four in-service teachers, who were in their graduate program, learned the authoring tool and were asked to develop their own educational game. Semi-structured interviews were used to collect the qualitative data, from which, results were stipulated. The results of this study showed that difficulties were at least in four facets: (1) the limitation of editing tool, (2) low self-efficacy, (3) very limited time available for developing courseware out of tight daily teaching job, 4 limited knowledge and skills for developing content (ex: theme, flowchart, learning materials, multi-media, questions, and story-line, etc.), etc. Many strategies were used to help new educational game developers to grow, including: (1) Increasing their directly experience: starting with writing simple and small scientific story and practicing the editing software. (2) Providing various experiences from experts' advices. (3) Provides various types of educational games as the scaffold.

9. O5-C3

FOSTERING PRE-SERVICE STEM TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE: A LESSON LEARNED FROM CASE-BASED LEARNING APPROACH

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As the recent demand for human resources in science, technology, engineering, and mathematics (STEM), the development of professional STEM teacher is called worldwide. It is becoming a critical need in teacher education in order to educate student teachers, and prepare pre-service and beginning teachers for high quality of teaching competency. To promote the competency for 21st century STEM teachers, the epistemology of technological pedagogical content knowledge (TPACK) is currently considered as the essential qualities of knowledge for highly qualified teachers. The aim of this study is explore the effect of case-based learning approach on TPACK competency of pre-service STEM teachers. In order to develop the pre-service teachers' competency regarding effective integration of technologies into teaching specific content areas, a series of innovative case study teaching in science and mathematics was presented to 43 participants of pre-service physics, chemistry, biology, mathematics, and computer teachers during a course of information and communication technology (ICT) in Education at Khon Kaen University, Thailand. After finishing a case presentation, the pre-service teachers were encouraged into a forum of critical open discussion by considering the potential impact of the case and the TPACK framework. They were investigated instructional design competency of using ICT tools into student learning process and their personal beliefs about ICT in educational process both before and after. The participant's reactions and learning was evaluated by using a self-reported questionnaire and an implementation log of content-specific learning process design, respectively. Results showed a change of their beliefs and the transformation of their TPACK competency in STEM teaching. In an effort to better serve the needs of high quality STEM teachers, the results of this study illustrated that the competency of TPACK could be particularly considered as a core attributes for future STEM teachers. By the way, case-based learning approach can play an effective part in preparing and professing the TPACK competency for STEM teachers.

- Oral Presentation 5-D
- Date: Friday, October 28, 2011
- Time: 09:00 ~ 10:00
- Room: #4 (2F)
- Chair: Mashita Abdullah (Nan Hwa Secondary School, Malaysia)

10. O5-D1

SMALL SCALE APPROACH FOR TEACHING AND LEARNING CHEMISTRY IN MALAYSIA

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Chemistry is an experimental science and its development and application demand a high standard of experimental work. Experiments are considered a subset of practical or laboratory work which is a didactic method of learning and practicing all the activities involved in Chemistry. The laboratory work also has great potential in promoting positive attitudes and providing students with opportunities to develop skills regarding cooperation and communication. Central to the teaching-learning approach in the chemistry curriculum is the mastery of scientific skills, which comprise process skills, manipulative skills and thinking skills. Students require the hands-on practical and personal laboratory experiences to acquire the skills. The Malaysian chemistry Form Four syllabus comprises nine topics with fifty experiments and the Form Five syllabus comprises five topics with thirty five experiments. Introducing the small scale approach in chemistry practical work would help overcome problems associated with the practical activities since this technique allows the students to conduct experiments individually. It is an environmentally safe technique with a pollution-prevention approach accomplished by using miniature glassware and significantly reduced amounts of chemicals. This study reported the feasibility of using the small scale approach in Malaysian chemistry syllabus. The feedback from teachers and students towards this approach also will be reported.

11. O5-D2

EXPLORING REASONING PROCESS IN COLLABORATIVE MODELING BY SMALL GROUP INTERACTION TYPE

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The purpose of this study was to examine the collaborative modeling and elements characterizing the learning environments of small groups. The group discussion was fostered by using triggering questions which can be answered based on experiences of hands-on activities. The analysis of the group discourse revealed that almost all groups understood the importance of valves in the one-way movement of blood through the heart. Despite participating in same activities, the groups showed different patterns of developing collaborative models of the following categories: persuasive, elaborated, and dialectic. Persuasive form of collaborative model was developed in a group where authoritative voice suggested by a leader was maintained. On the other hand, elaborated one and dialectic one were developed in a group where inclusive leader encouraged other members to present their own idea. As a result, a student's idea presented at first was elaborated as other ideas were added, or it was transformed into dialectic form of collaborative model which included emergent property of blood flow system. In addition to leader style, group ethos and teacher's intervention influenced the pattern of collaborative modeling through socio-cognitive interactions.

12. O5-D3

IMPROVEMENT OF STUDENTS' PROBLEM FINDING AND HYPOTHESIS GENERATING ABILITY: GIFTED SCIENCE EDUCATION PROGRAM UTILIZING MENDEL'S LAW

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In the process of establishing the principle of genetics, Mendel discovered problems based on various observations. Mendel's scientific thinking ability can be effective if this ability is embedded in gifted science education programs. The study aims to develop a science gifted education program utilizing Mendel's scientific thinking ability shown in the principles of genetics and examine students' changes in scientific thinking ability before and after the program implementation. For the program development, first, the characteristics of Mendel's scientific thinking ability in the process of establishing the principle of genetics were investigated and extracted the major elements of inquiry. Second, the science gifted education programs was developed by applying the inquiry elements from the Mendel's Law. The program was implemented with 25 students of 8th graders who attend the science gifted education center affiliated with universities during June 2011. The Mendel's scientific thinking ability was classified into induction, deduction, and abduction. The elements of inquiry extracted from the Mendel's scientific thinking include making observation, puzzling observation, proposing causal questions, generating hypothesis, drawing inference, designing experiment, gathering and analyzing data, drawing conclusions, and making generalization. With applying these elements, the program was developed with four phases: 1st - problem finding; 2nd - hypothesis generating; 3rd - hypothesis testing; and 4th - problem solving. After implementation, students' changes in scientific thinking ability were measured. The findings from the study are as follows: First, students' abilities of problem finding and hypothesis generating were significantly ($p<.05$) increased. Second, students' conceptual understandings of principle of genetics were improved.

- **Oral Presentation 5-E**
- **Date: Friday, October 28, 2011**
- **Time: 09:00 ~ 10:00**
- **Room: #5 (2F)**
- **Chair: Nilda Balsicas (St. Dominic College of Asias, The Philippines)**

13. O5-E1

MOTIVATION FACTORS AMONG NON-SCIENCE STUDENTS

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Third year college non-science in food microbiology class were exposed to an eight hour class and an hour lecture. Observations suggest that students are less motivated for subjects outside their major. We report on research that examines factors that motivate non-science students to engage in meaningful learning. Science motivation was measured using Science Motivation questionnaire. Final term grades were correlated with their level of motivation. Quantitative data were triangulated with the qualitative data obtained from the reflection paper of the 30 students. Findings suggest that non-science students are motivated to study science because they want to earn good grades and are afraid to fail, to enjoy doing science at the lab, teachers who have mastery of the subject and understanding of their problems. They prefer science topics and activities which have career relevance, exciting laboratory environment, and those that develop their science skills. The research findings provide insights and implications to the preferred learning paradigm of the non-science students.

14. O5-E2

UNIVERSITY STUDENTS' UNDERSTANDING OF WAVE-PARTICLE DUALITY

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The purpose of our study is to investigate university students' interpretation about wave-particle duality. There is no consensus on the interpretation about quantum theory even among the physicist and

physics educator communities. Thus in this study several interpretations concerning duality found in the textbooks and in previous studies which treated the duality were evaluated critically. The evaluation provided the guide for our empirical research on students' understanding of the duality. Students' ideas were gathered through semi-structured interview and a written questionnaire. By analyzing the data qualitatively, the following characteristics of students' understanding of the duality were extracted. 1) Many students seemed to have only naïve interpretation about the duality. 2) Many students accepted the wave-like property of electron directly from the interference-like pattern without considering the behavior of electrons. 3) Many students showed a bias to particle-like nature of electron even in explaining interference. 4) Many students had accepted the interpretation on the duality, given from textbooks or instructors, without any deliberation. Students missed the opportunity to resolve the seeming paradox of the duality and to elaborate the meaning of duality. This would be serious obstacle to the students' conceptual understanding concerning quantum theory.

15. O5-E3

THE EFFECT OF READING SCIENCE POPULAR BOOKS ON THE NATURE OF SCIENCE OF COLLEGE STUDENTS

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This study aimed at investigating students' understanding of nature of science (NOS) via science popular books reading. A general education course, two credit hours a semester, which was designed to read the science popular book "Evolution: The Remarkable History of a Science Theory" was developed at medical university in Taiwan. Thirty-four students, aged 18~20, from fifteen different departments of the university participated in this course. Students were randomly assigned to seventeen groups with two members per group. They were arranged to read the textbook, to discuss both within-group then to discuss between-group, to take notes, and to fill out questionnaires before/after learning activities. Lectures on idea of historical view and philosophy of science (eg. scientific revolution) were also delivered in class. A five point likert scale based on the works of McComas and his fellows (McComas, Clough, & Almazroa, 1998; McComas, & Olson, 2002) was developed to explore students' understanding of NOS. Fourteen items in the scale included: (1) Scientific knowledge is tentative; (2) Scientific knowledge relies heavily, but not entirely, on observation, experimental evidence, rational arguments, and skepticism; (3) There is no universal step-by-step scientific method; (4) Science is an attempt to explain phenomena ; (5) Laws and theories serve different roles in science ; (6) Science is a human endeavor and all cultures (can) contribute to science ; (7) New knowledge must be reported clearly and openly; (8) Scientists require: accurate record keeping, peer review, replicability, truthful reporting; (9) Scientists, observations are theory-laden, must be open to new ideas; (10) Scientists are creative ; (11) Change in science occurs gradually and occurs through revolution ; (12) Science, has global implications, is a part of social and cultural tradition ; (13) Science and technology impact on each other; science has played an important role in technology; (14) Scientific ideas are affected by their social and historical milieu. The paired samples t-test was used to compare students' responses of pre-test and post-test. The result showed that item 9 and item 13 were statistically significant ($t = -2.781$, $p = 0.009$ and $t = -2.586$, $p = 0.014$, respectively). It meant that students' understanding of "Scientists, observations are theory-laden, must be open to new ideas" and "Science and technology impact on each other; science has played an important role in technology" were different after learning. In other words, students changed their view of these NOS via reading Larson' Evolution: The Remarkable History of a Science Theory.

- **Oral Presentation 5-F**
- **Date: Friday, October 28, 2011**
- **Time: 09:00 ~ 10:00**
- **Room: #6 (2F)**
- **Chair: Seungho Maeng (Seoul National University of Education, Korea)**

16. O5-F1

FOR THE LEARNING PROGRESSIONS IN ASIAN SCIENCE EDUCATION RESEARCH: ANALYTIC AND COMPARATIVE REVIEW OF ASIAN, EUROPEAN, AND AMERICAN STUDIES ON CONCEPTUAL TRAJECTORIES IN SCIENCE LEARNING

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Learning Progression (LP) in science education is a recently focused issue among science educators in the U.S. as well as several European countries in order to show learning pathways or developmental corridors of understanding science concepts. Of interest, we, Asian science educators also have studied students' conceptual understanding across the levels from elementary to secondary school. The main purpose of this review is to describe the differences and similarities among the studies of conceptual trajectories of science topics implemented in Asia, Europe, and the U.S. The reviewed publications are drawn from journal special issues (e.g., IJSE, EERJ, and JRST), conference proceedings, and some monographs in other several journals. This review is focused on the studies delving into science topics in LPs, Teaching-Learning Sequences, and Conceptual Trajectories. Findings of this review revealed that Asian studies on conceptual trajectories have explored what concepts students understand better or worse in which grades from elementary through secondary. They also identified the nature of students' difficulties in learning scientific concepts. However, Asian approach to conceptual trajectories of science topics needs more consideration of horizontal/vertical progression or pathway of conceptual learning as well as applying various assessment tools to diagnosing students' conceptual understandings of science topics. European studies on teaching-learning sequences based on the Didaktik tradition in Germany and Nordic countries showed detailed structure and scenarios to construct students' development of understanding science concepts. In addition, European didaktik approach to conceptual learning has effective iterative processes of developing a scenario or pathway to learn a science concept. Instead, it is not clear how these studies describe the way of teaching with diagnosis of students' perceptions. While the studies on Learning Progressions in the U.S. have diverse views on the LP itself, there are some distinctive features of LP studies from Asian and European perspectives. First, the studies on LPs show hypothetical trajectories or learning pathways from lower anchor to upper anchor. Second, LPs intend to embed the hypothetical trajectories in specific instructional strategies when describing the intermediate steps of the LPs. Third, LP studies employ various assessment tools and methods for diagnosing and measuring the levels of students' understanding science concepts (e.g., construct map, ordered-multiple choice items, clinical interviews, Wright map, etc.). Fourth, LPs tries to implement the alignment of curriculum, instruction, and assessment in developing and using the LPs. In addition to these findings, this review suggests some future directions and key points for the research on LPs in Asian science education.

17. 05-F2

COMPARISON BETWEEN THE THINKING STYLES OF STUDENTS IN A SCIENCE SCHOOL AND A NORMAL SECONDARY SCHOOL

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This study investigated the thinking styles of gifted science students and non-gifted students and examined whether the thinking styles based on Sternberg's (1988, 1997) theory of mental self-government could predict their achievement in science. The sample consisted of 145 gifted Grade 7 students from a Science College and 242 non-gifted Grade 7 students from a mainstream school in Brunei Darussalam. In this study, the Sternberg-Wagner Thinking Styles Inventory (Sternberg, 1997) was used. Results showed that there were statistically significant differences in thinking styles between gifted science students and non-gifted students. On analysis using the standard multiple regression procedures, it was found that the subscales of thinking styles could be significant predictors of achievement in science. Furthermore, there were also significant differences in the thinking styles between male and male and between female and female students from both types of schools. The paper concluded with the implications and limitations of the study.

18. 05-F3

TOWARD AN ACADEMIC DISCIPLINE OF SCIENCE EDUCATION WITH CHINESE FEATURES

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Science education as an academic discipline in its own right had its origin in the US in the early decades of the twentieth century, and it has flourished and spread to other countries since the 1960s when the first wave of science education reforms began. While the Anglo-American science education research is the mainstream internationally, a new paradigm of science education research has emerged, which is based on the tradition of German Bildung-centered Didaktik. Since Chinese modern education research has drawn on both American and German traditions, plus a Russian influence in the 1950s which is similar to the German tradition, science education as an emerging field of research in Mainland China, although a new addition to the educational sciences, has been characteristic of both paradigms with Chinese features. This study is aimed at a comprehensive description and analysis of the status quo of science education research in Mainland China, followed by a discussion of some issues, problems and the possible way forward. In line with the multiple educational research traditions, both foreign and Chinese, it is important to argue that science education as a new academic discipline in its own right should be established in the academic hierarchy of institutionalized disciplines in Mainland China. Within such a new academic discipline, the traditional research on didactics of physics, chemistry, and biology should be maintained, since it has had positive impact on science teacher education. With such features in mind, it is concluded that a more integrated discipline of science education in its own right should be developed as one of the many sub-disciplines of pedagogy in the German sense of the word.

- **Oral Presentation 6-A**
- **Date: Friday, October 28, 2011**
- **Time: 13:00 ~ 14:20**
- **Room: #1 (1F)**
- **Chair: Sau Kheng Au (Ministry of Education, Singapore)**

19. 06-A1

TEACHERS' INQUIRY PRACTICES AND BELIEFS ABOUT IMPLEMENTING INQUIRY-BASED LABORATORY EXPERIMENTS

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One of the greatest challenges in teaching and learning science is trying to understand what inquiry is and how it should be carried out in the science lessons. The idea of inquiry can be perplexing to many science teachers and also teachers' beliefs about inquiry-based laboratory work may influence the implementation of any inquiry-based instruction in the schools. The teachers' beliefs may inevitably impact on their classroom teaching practices and in turn influence students' learning and laboratory experiences. In order to provide a picture of how teachers engage their students in scientific inquiry, chemistry research projects of the Teach Less, Learn More (TLLM) School-based Curriculum Innovation from 2007 to 2011 were analysed for an explicit understanding of the science inquiry practices in Singapore. This paper describes a study on the inquiry practices in secondary chemistry lessons and laboratory work of some Singapore secondary schools and the preliminary findings of 171 chemistry teachers' beliefs about

implementing guided laboratory experiments. The Guided Inquiry Scale (GIS) which was developed and validated to measure Hong Kong chemistry teachers' beliefs about implementing inquiry-based laboratory work for secondary school was used in this study to measure the chemistry teachers' beliefs on inquiry-based laboratory experiments.

20. 06-A2

THE EFFECT OF SCIENCE WRITING HEURISTIC ON CONCEPT FORMATION OF LIGHTS IN MIRRORS/ LENSES AND SCIENTIFIC ATTITUDES

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This study investigated the effectiveness of the Science Writing Heuristic (SWH) on the concept formation and students' retention on the topic of mirrors and lenses. Also we explored the interaction effect of concept formation and retention with scientific attitudes. We developed lesson plans incorporating SWH on Mirrors and Lenses unit for elementary school students. An experimental group made up of 25 5th grade students had been instructed for 6 classes with the science lesson plans mentioned above while a control group of 27 students was taught according to the lesson plans from the teacher's guides in school science curriculum published by Ministry of Education. The results of this study showed that SWH has positive effect on the concept formation on the topics of mirrors and lenses for both male and female students. However in the interaction effect of the concept retention and scientific attitude, SWH was effective only for the female students. Hence we suggest SWH should be evolved and applied to the science class more carefully by considering intrinsic characteristics of students especially in gender. Also we suggest the need to modify the SWH to cater for different students' needs and their environment in order to create more effective science classes.

21. 06-A3

UNDERSTANDING MIDDLE SCHOOL STUDENTS' BIOLOGICAL TAXONOMY PROCESSES THROUGH SMALL-GROUP ARGUMENTATION

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The purpose of this study was to identify how students perform biological classification activity through small group argumentation and explore how small group argumentation promotes students' understanding of scientific taxonomy. We developed inquiry activities for 'Composition and Diversity of Organisms' unit in 7th grade science curriculum and carried them out with 40 students. The activities involved constructing 'taxonomy tree' in small groups with bolts and nuts, animal cards, and plant cards. Student's classification process from test results, worksheets, and discourse were analyzed. Students attempted to apply inductive reasoning as warrant to support their claims, using given data and their knowledge. They also tried to find a lot of new and unique criteria and apply them to 'taxonomy tree'. However most of criteria presented by student were based on appearance of organism which had a limit to explain classification system. As a result of small group argumentation, some groups were able to select more appropriate and critical criteria for classification among various features of organism and classify the organism based on them. Though many students learned how to construct the taxonomy system based on evidence and warrant through argumentation, some of them failed to determine which criteria is biologically more valid and had problem with understanding hierarchical relations among various criteria. Overall, the study was able to provide information about students' understanding of taxonomy and classification process through argumentation. It suggests that teachers should encourage students to understand biologically validity and order of taxonomy criteria.

- **Oral Presentation 6-B**
- **Date: Friday, October 28, 2011**
- **Time: 13:00 ~ 14:20**
- **Room: #2 (1F)**
- **Chair: Sungmin Im (Daegu University, Korea)**

22. 06-B1

USING COGENERATIVE DIALOGUES TO EXPLORE THE EXPERIENCES OF KOREAN ENGLISH LANGUAGE LEARNERS IN THE SCIENCE CLASSROOM IN THE US

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There has been increasing emphasis on the use of cogenerative dialogues in the research and practice of science education (Emdin, 2007; Martin, 2006; Scantlebury & LaVan, 2006). Cogenerative dialogues (Tobin & Roth, 2006) are conversations in which stakeholders critically examine and reflect on shared events and activities, so as to ""cogenerate"" collective resolutions in an effort to catalyze change and to promote science learning. Although cogenerative dialogue has been shown to be an effective tool for connecting research and practice in urban science classrooms in the United States, Canada, and Australia, this methodology has rarely been conducted with non-native English speakers (Martin, Wassell, & Scantlebury, in press). This study is unique and provides important information about the viability of implementing this research model with a different population of classroom teachers and students. Specifically, this study describes the experiences of Korean immigrant students who are English Language Learners (ELL) students in science classrooms in urban schools in the United States. By employing cogenerative dialogue and video analysis as tools to support teachers to learn about ELL students' understandings about language and science, educational researchers can identify science teaching strategies that can better support the needs of linguistically diverse learners. Involving ELL students in cogenerative dialogues about their experiences in school science provides teachers with valuable insights into how their students learn. In addition, these conversations offer ELL students a forum for talking about the purpose of school and a social space for formulating ideas about their participation in science class and the quality of their interactions with peers and teachers. Using video and audio analysis captured from classroom interactions and cogenerative dialogues, we explore the role of linguistic proficiency and socio-cultural difference as important factors influencing the efficacy of this methodology. Research involving teachers and ELL students in discursive practices about the purpose and goals of science education has the potential to transform approaches to science teacher education and teacher education in countries where there are significant immigrant populations in K-12 schools. However, this study is particularly important because the findings have implications for informing current methodological practices and theoretical understandings about how cogenerative dialogues can be adapted so they can be utilized successfully in educational contexts that differ from the Western educational systems where cogenerative dialogues were originally developed. Specifically, we discuss important implications for future research on cogenerative dialogues in different cultural contexts, including science classrooms in Asian and South-east Asian countries.

23. 06-B2

ANALYSIS AND DEVELOPMENT OF EXPERT CONCEPTION IN JUNIOR HIGH SCHOOL NANOTECHNOLOGY CURRICULUM IN TAIWAN

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In order to understand the effectiveness development of junior high school nanotechnology curriculum and analysis knowledge of nanotechnology conception in Taiwan, researchers formed a team by invite union of junior high school nanotechnology teaching teachers, nanotechnology expert, and science education expert for making joint efforts in expert conception of junior high school nanotechnology curriculum development in Taiwan. As conclusion: **1.** Completely transform the expert concept map of junior high school "nanotechnology" into declarative knowledge statement, including: the definition of "nanotechnology", natural phenomenon, skills development , products, and affective attitude. **2.** Junior high school nanotechnology statement transform expert concepts map into declarative knowledge statements, emphasizing the meaning between scientific terms and increasing the number of science principles description. **3.** Transfer expert concept map and declarative knowledge statement into junior high school nanotechnology opened-questionnaire which divided into 18"proposition situation". We ask student to read the "proposition situation", and then answer one to three open-ended questions.

24. 06-B3

THE EFFECT OF LEARNING CYCLE MODEL ON CONCEPTUAL UNDERSTANDING OF SOUND FOR THE STUDENTS WITH INTELLECTUAL DISABILITY

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Students with intellectual disability have difficulties in understanding science concepts due to their limited cognitive abilities and learning materials in consideration of individual diversities. Science is as important for the disabled students as it is for the non-disabled students, for it can help them solve problems in everyday life and develop reasoning skill through scientific activities like manipulation using specific objects. However, there have been few researches about teaching and learning science for the students with intellectual disability. In order to understand concepts of sounds for the students with intellectual disability, the authors extract distinction, occurrence, transmission, reception, and character as sub-concepts of it in this research. The authors developed a 16-lesson instruction program based on the Learning Cycle model with the process of research-design-verification-modification. The program was applied to four students with intellectual disability of two middle schools during eight weeks. To identify the effect of the program the authors investigated students' understanding of sound concept before and after the lesson using sound concept inventory tool developed by a preliminary study and analyzed the change. As a result, students' conceptual understandings of sound before applying the Learning Cycle model were context-dependent and undifferentiated, while their understandings at the end of the lessons were enhanced than before and changed into more scientific. In spite of positive changes, they still have difficulties in understanding of sounds concepts, especially, of tone and pitch. This study can infer the Learning Cycle model would be an effective instructional approach to teach basic scientific concepts for students with intellectual disability.

25. 06-B4

THE EFFECTIVENESS OF CONSTRUCTIVIST APPROACH-BASED EXPERIMENTS IN TEACHING SELECTED PHYSICS CONCEPTS

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The purpose of this study was to develop constructivist approach-based experiments and to determine its effectiveness in teaching some physics concepts specifically in mechanics. In the conduct of the study, the quasi-experiment following a non-equivalent control group design was used. Two sections of 2nd year Bachelor of Science in Information Technology students of Isabela State University - Cauayan City Campus in Cauayan City, Isabela, Philippines were involved. The study started with the administration of pre-test and attitude inventory test. The teaching making use of constructivist approach-based experiments for the experimental group and traditional experiments for the control group followed. Finally, it ended with the administration of the post-test and attitude inventory test. The scores in the achievement test and standardized attitude inventory test were compared and the significance of their difference was determined using the t-test. Before the conduct of the study, the control group and the experimental group were equal in terms of cognitive level in physics. However, the students exposed to the constructivist approach of laboratory teaching had significantly higher post-test scores and higher mean gain scores than the students exposed to the traditional approach after the study was conducted. The study also revealed that the experimental group developed a more positive attitude towards physics than the control group. Moreover, there was a significant difference between the post- achievement scores and post attitude scores of the students exposed to constructivist approach-based experiments and traditional experiments. As revealed in the study, the Constructivist Approach-Based Experiments are effective in enhancing students' achievement and in developing a more positive attitude towards the subject than the Traditional Experiments. Furthermore, the students' achievement and attitude towards the subject can be intensified when they work cooperatively, providing them with more opportunities to apply their own skills and make their own decisions thus overcoming their misconceptions on the subject. The constructivist approach-based experiments really affirmed its worth and advantage as instructional material in teaching physics concepts.

- **Oral Presentation 6-C**
- **Date: Friday, October 28, 2011**
- **Time: 13:00 ~ 14:20**
- **Room: #3 (1F)**
- **Chair: Supawadee Tonwongkaew (Khon Kaen University, Thailand)**

26. 06-C1

ENHANCING TEACHERS' KNOWLEDGE OF SCIENCE AND MATHEMATICS TEACHING FOR IMPROVING STUDENTS' ANALYTICAL THINKING

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This research aimed to enhance teachers' knowledge of science and mathematics teaching for improving primary school students' analytical thinking. Participants included 3 science teachers and 3 mathematics teachers in Tadsabal Srimuangphol School, Khon Kaen, Thailand. Research methodology regarded participatory action research (PAR). The activities of PAR were set concerning with participants' needs and problems. These activities included meeting of knowledge management; workshops of teaching strategies, assessing students' analytical thinking and developing lesson plan; and supervision by Khon Kaen teacher network. Teachers' pedagogical knowledge of enhancing students' analytical thinking was interpreted through teachers' writing journal, observation, and interviewing. The findings indicated that teachers gained motivation, pedagogical knowledge and skills, and also perceived pedagogical content knowledge of teaching for improving students' analytical thinking.

27. 06-C2

INFLUENCE OF TEACHING OPTION AND TEACHING EXPERIENCE ON SCIENCE TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE OF ENVIRONMENTAL EDUCATION

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Environmental Education is usually taught across the curriculum in most of the countries. This teaching approach had been a challenge for the teachers to implement especially in the Malaysian curriculum context. Thus, science teachers require Pedagogical Content Knowledge of Environmental Education (PCK-EE) to implement Environmental Education across curriculum. The purpose of this study was to explore the influence of teaching option and teaching experience on science teachers' PCK-EE. Five components of PCK-EE were investigated in this study, which were: a) knowledge of curriculum, b) knowledge of content, c) knowledge of student, d) knowledge of teaching strategies, and e) knowledge of evaluation. 347 secondary science teachers from the state of Selangor participated in this survey study. The questionnaire used had 60 items. The findings revealed teaching option have significant influence on science teachers' knowledge of content (p=.000), knowledge of student (p=.000) and knowledge of teaching strategies (p=.016). In the case of teaching experience, it was found that there is a low correlation on two components of PCK-EE i.e. knowledge of content (r=.174) and knowledge of evaluation (r=.170). Implication of this study leads to the suggestion of the enhancement of teachers' education program especially at pre-service level. This is because pre-service training is found out to be the factor that determines teachers' future teaching option.

28. 06-C3

ANALYSIS CHEMISTRY TEACHER'S CONCEPTION OF TEACHING WITH INQUIRY

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Teaching with inquiry is recommended to science teachers. In China, the National Curriculum Standards of Chemistry also emphasize Science Inquiry. Some teachers found it is very low efficient teaching with inquiry while some found it is perfect. Why? This Research is to explore teacher's conception of teaching with inquiry, analysis why some teachers teach with inquiry well, and find the teachers' conceptions system of teaching with inquiry who teach with inquiry well.
This research included two parts. The research method of the first part is casual interviews based on case studies. In this part, researcher observed three groups of teachers. Each group of teachers was studying one teaching subject which be taught with inquiry. The number of teachers in each group is: 17, 3, 6. Besides observation, researcher interviewed teachers when necessary. By this method, researcher can find what teachers think and how they think when teaching a subject with inquiry. Researcher can also find the relationship of teachers' different conception and different behavior of teaching with inquiry. So

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researcher can construct the different level of chemistry teacher's conceptions system of teaching with inquiry. But the shortcoming of this method is the achievement may be disordered, so we need another research to remedy it. The research method of the second part is the standard casual opening interviews. In this part, ten teachers were been interviewed. Before interviewing, a series of questions had been prepared. Researcher asked teacher the same questions with the same order, and researcher maybe make a detailed inquiry when necessary. By this method, researcher can test and verify the conceptions system of teaching with inquiry, then modify it and complement it. To search the excellent teachers' conception system of teaching with inquiry, half interviewees are prize-winner in national competition of chemistry teaching. By the two research methods, researchers got the conclusions are below: **1.** Teachers' conceptions system of teaching with inquiry have contain the different conception forms such as the concrete declarative, procedural and conditional, the schema; **2.** The element of conceptions system of teaching with inquiry is the value of teaching with inquiry, the feature of teaching with inquiry, the procedure of teaching with inquiry, the requirement of teaching with inquiry, and the schema of teaching with inquiry. **3.** The structure of the schema of teaching with inquiry is: (To a subject) • whether need inquiry teaching • decide the question to be inquired • choose the path of inquiring • decide the inquiry element to be opened to students • prepare for the difficulty of inquiry • be familiar with the strategy to ensure the efficient of students' inquiring. **4.** The excellent teachers intend more to methods of subject-matter in terms of students' understanding students' scientific capacity among three concrete teaching conceptions; they intend more to break out the limits of teaching contents and students' ability in terms of using teaching conceptions; and last their teaching conceptions have a multiple schema forms.

29. 06-C4

DESIGN AND USE TWO-TIER TEST FITTING FOR RASCH MODEL TO INVESTIGATE GRADE 10-11 STUDENTS' UNDERSTANDING OF PHOTOSYNTHESIS

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The development of understanding photosynthesis is one of the greatest achievements in biology. The importance of learning the concept of photosynthesis during K-12 curriculum is also apparent, because it is by this biochemical process that atoms of carbon within organic cell are fixed from inorganic environment. Given the complexity of this concept, appropriate and clear expectations of students' understanding of photosynthesis are necessary. Majority of science/biology curriculum documents in U.S., Australia, Canada and Britain unanimously state that students graduated from grade 12 can use an atomic-molecular account of photosynthesis to explain macroscopic and large-scale phenomena (e.g., plant growth, plants as a carbon sink) in terms of rearrangement of atoms. To achieve this goal, students should learn many different aspects of the concept of photosynthesis to construct deep understanding. Teachers in senior high school should design teaching plan base on what students have already understood from junior middle school and what students would understand through learning following their cognitive development. So it is important for teachers to know students' cognitive ability in senior high school compared with the difficulty of each aspects of the concept of photosynthesis. To accomplish comparison above, this study develops a questionnaire in which the understanding of concept of photosynthesis is categorized into seven aspects within 23 items initially, which includes factors necessary for photosynthesis (ab., FN), matter and energy change during reaction (ab., ME), factors impacting the rate of reaction (ab., IF), photosynthesis and autotrophy (ab., AT), photosynthesis and respiration (ab., PR), photosynthesis and plant growth (ab., PC), and photosynthesis and cycle of elements (ab., EC). Each item is designed in the form of two-tier diagnostic test and the whole questionnaire is developed by 10 steps proposed by Xiufeng LIU to assure it is fit for Rasch model that can converts examinees' abilities and items difficulties to the same linear measure. Through pilot study from 53 students of grade 11, 22 two-tier items fitting for Rasch model remains to form the final questionnaire. This study use Rasch model to convert original investigation data into Rasch measure, which is collected by the questionnaire for 179 students of grade 10-11 in Beijing. And the Wright Map depicted by Rasch modeling shows that: 1) the vast majority of students' cognitive abilities match difficulties of IF, PR, EC, AT, and ME; 2) almost all of students have relative higher cognitive ability than the difficulty of FN; 3) the difficulty of PC is relative higher than most of students' cognitive abilities but not for all students; 4) the cognitive difficulties among different parts of the concept of photosynthesis follows a pattern from easy to difficult, which is "FN → IF → PR → EC → AT → ME→ PC". It implies that: 1) PC may be appropriate to challenge students' higher level thinking; 2) students should learn through the way of IF → PR → EC → AT → ME to understand PC if just merely consider the order of relative difficulties; and 3) FN should not become main aspect for students to learn in senior high school.

- Oral Presentation 6-D
- Date: Friday, October 28, 2011
- Time: 13:00 ~ 14:20
- Room: #4 (2F)
- Chair: Seyoung Hwang (Seoul National University, Korea)

30. 06-D1

A REVIEW OF RESEARCH ON TEACHER PROFESSIONALISM AND IDENTITY IN ENVIRONMENTAL EDUCATION

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In this presentation, we introduce a review study of teacher professionalism and identity in environmental education in Korea. The aim of review was to propose a framework for which teacher professionalism in environmental education can be defined, con-

ceptualized, and critically examined. We reviewed over 100 research studies published since 1990 in major scholarly journals. This comprehensive study includes not only science-related topics and teaching contexts, but also other curricular foci, so as to examine various ways in which environmental issues are taught in the school context. We specifically focused on the studies that address issues of teacher preparation, beliefs and knowledge for implementing environmental education in various school context, and gaps between teachers' preferred ways and the realities. We also included studies that analyzed effective ways of improving teacher knowledge and competence. We developed a review framework from three perspectives based on the preliminary review of all selected studies and literature review: and they are i) historical perspective, ii) discourse of teacher professionalism, and iii) influences on teacher identity formation. Firstly, from the historical perspective, we tried to identify trends and changes in the topics and teaching methods as well as research methods over time. Secondly, we analyzed what constitutes teacher professionalism in environmental education in the research discourse, particularly in terms of rationales in defining teacher's knowledge and competence in certain ways. Furthermore, we critically examined whether there were dominant and marginalized discourses, or ways of thinking about and defining teacher professionalism in environmental education. Thirdly, we investigated how the studies framed teacher's participation into environmental education, and how teachers in the studies were represented. This enabled us to critically examine the reasons why interdisciplinary curricular activities such as environmental education, in spite of its importance, remain marginalized in the school education. Based on the study's results, we discuss how future research can help teachers get involved, and develop their own ways of teacher professionalism in environmental education.

31. O6-D2

METACOGNITIVE ORIENTATION OF PHYSICS CLASSROOM IN THAI CONTEXTS

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This research aimed to describe the direction of the development of metacogniton. This is different in the context structure of a teaching and learning environment in the classroom between urban and country. Metacognition refers to knowledge of an individual's control and awareness of the learning process. The direction of development of metacognition is to develop students as life-long learner's metacognition, targeted group-level secondary schools period grade 10, Area 1 and 3 in Khon Kaen Province. This research is quantitative and qualitative research rely interpretive paradigm. The styles of research are to study for a holistic analysis. This research is the application of tools is call MOLES-S used in the evaluation of putting the concept. The metacognitive orientation of a learning environment is the extent to which that environment supports the development and enhancement of students' metacognition. Social constructivism was the guiding referent informing the instrument's orientation and development. Aimed to understand the meaning of metacognitive by describing the social context of teaching and learning in physics are different in the context of Thai society, the concept and the belief that truth occurs to the thinking process of the students. Depending on the context in which students lived. The results were that the new environment of teaching and learning in the classroom or even activities that students used in the classroom learning the physical sciences. Result in a student's cognitive processes. Which individual students will have a lot less, it depends on learning development of individual students. In social culture that occurred in the communities where students lived. Are trends to be support to Knowledge many students think, which is associated with a culture of learning in the context of society. Findings from the use of this instrument complement what is already known from research studies to be generally the case in relation to science classrooms' metacognitive orientation.

32. O6-D3

FACTORS CAUSING SCIENCE LEARNING FATIGUE IN SCIENCE MUSEUMS AND SCHOOLS

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This study aims at investing science learning fatigue caused by various learning-related factors in science museums and in schools. At the first stage, the framework for main factors causing science learning fatigue was developed on the basis of a review of the literature. The main factors of science learning fatigue in science museums and in schools were divided into three dimensions(i.e. personal context, physical-environmental context and socio-cultural context) following the idea of the contextual model of learning proposed by Falk & Dierking(2000). The first free-style questionnaire was given to 597 elementary, middle and high school students. From the first questionnaire, 50 main factors of science learning fatigue in science museums and in schools were identified. And these were grouped into 9 categories. Through these, the framework consisted of 3 contexts, 9 categories, 50 factors of science learning fatigue was developed. On the basis of the framework of the factors of science learning fatigue, the second questionnaire, in which students were asked to respond on a Likert scale how much they feel fatigue with the 50 factors, was developed and asked to 610 elementary, middle and high school students. Through statistical reviews with reliability analysis and factor analysis, features of the factors of science learning fatigue in science museums and in schools were analyzed and compared. It is expected that the findings of this study would enhance to a considerable extent science learning in science museums and schools by providing the features and details of the factors of causing science learning fatigue.

33. O6-D4

DEVELOPMENT OF EDUCATIONAL PROGRAMS FOR REINFORCEMENT OF SCIENCE AND TECHNOLOGY ETHICS LITERACY AND ITS APPLICATION ON STUDENTS MAJORING SCIENCE AND ENGINEERING

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The purpose of this study was to develop advanced educational materials and contents of science and technology ethics. The purpose of the study also include to improve the students' conscious attitude towards science and technology ethics which may be raised in the process of research and result formation through the developed science and technology ethics education programs. The programs of science and technology ethics consist of 12 subject matters in 3 categories (science and technology research; advanced science-technology; Science-technology and society). And these are as follows; first, 'Science and technology research' covers process of research, publication of research results, operations of research laboratory and research integrity. Second, 'Advanced science-technology' includes information technology, bio technology, environmental issues and nano technology. Third, 'Science-technology and society' deals with science-technology and risk, science-technology and citizen participation and science-technology and women. Each program was developed using various teaching and learning methods, such as cooperative learning, discussion, role playing, filed trip and problem-based learning. A total of 95 engineering major students from two colleges implemented the programs in their elective class during the first semester of 2011. After applying the ethics programs, researchers examined both students' changes in perceptions and effects of the programs. As a result of the study, students actively engaged in the discussions and their perceptions of science and engineering ethics were changed positively. Furthermore, the students perceived that their decision-making ability became improved. The developed programs can be used for core and elective classes in science and engineering colleges. Also they can be utilized in helping science and technology experts with conscious awareness of ethical issues.

- **Oral Presentation 6-E**
- **Date: Friday, October 28, 2011**
- **Time: 13:00 ~ 14:20**
- **Room: #5 (2F)**
- **Chair: William Palmer (Curtin University, Australia)**

34. 06-E1

JACOB ABBOTT (1803-1879): LIGHTING THE WAY FOR YOUTH

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Jacob Abbott was born in Hallowell, Maine on 14 November 1803. He was the second child of seven children and eldest son of Jacob and Lydia Abbot (note the different spelling of the name). He had a happy childhood with loving parents. Jacob and each of his four brothers attended Bowdoin College, near Brunswick, from which they graduated and all became ministers and/or teachers. He studied at Andover Theological Seminary in 1821, 1822, and 1824 and he was a tutor there in 1824-1825. From 1825 to 1829, he held a position as professor of mathematics and natural philosophy at Amherst College. This basic experience in teaching and research in the sciences helped his future career. His life spanned several careers, as a school and university teacher, as a headmaster, as a pastor, a children's writer and as a journalist. Although the majority of his writings (more than two hundred books) were for young children on topics other than science, he also produced a series of books for children of primary/early secondary age which were exceptionally popular. The hero of many of these books is Rollo, a young boy who is the central character; Rollo is helped by his Uncle George (and others) to carry out experiments and discuss them. There are a number of articles that review Jacob Abbott's merits as the major children's author of the period. However he was also an influential educator of boys and girls who communicated a scientific view of the world to children within his fiction; he wrote children's books explaining scientific principles such as his series on museums, heat, light, air and water; he also communicated to adults through technical and travel articles in Harper's Monthly. Jacob Abbot was influential in science communication and should be remembered as one of those who lit the way towards greater understanding for all in science.

35. 06-E2

THE ORGANISATION OF SCIENCE (RIKA) EDUCATION IN JAPANESE ELEMENTARY SCHOOLS

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With reference to the idea of the organisation of science, in this research the factors of the organisation of science (Rika) education are set out as follows; (1) establishment of the department (ministry) for education and promulgation of regulations (orders) on education, which means that scientific subjects are firmly placed in the school curriculum, (2) establishment of teacher training institutions with standardized training programmes, and (3) the organisation of a teaching professional community and the making of a professional culture. The Japanese government established the Department of Education in 1871, and the following year it established a school system which promoted a utilitarian curriculum involving separate scientific subjects. With the aid of foreign government advisors, normal schools for elementary school teacher training were also created in prefectures. In 1885, the cabinet system of Japanese government was established and the Department of Education was replaced by the Ministry of Education with its highly centralised government control over the whole of the education system. The Elementary School Order, which outlined subjects and their standards, was promulgated by the Ministry in 1886, and an integrated scientific subject known as 'Rika' was firmly placed in the higher elementary school curriculum by order. The objectives and content of 'Rika' were stated in detail by the Regulations for the Enforcement of the 1891 Elementary School Order. The normal school system was recreated by the Normal School Order in 1886. By the end of 19th century, many regional education associations and the whole Japanese education association had been established. These education associations played important roles in creating professional communities of teachers and developing professional cultures in Japan, e.g. giving opportunities for lesson study and publishing journals and books on education. The Museum of Education also played important roles to promote education, especially science education. Through these processes, the organisation of science (Rika) education was accomplished in the twenty years leading up to the end of 19th century. Until the new subject 'Rika' was introduced in 1891, scientific subjects were mainly taught using translated textbooks. The 'science' which was introduced in the 1870s and 1880s was modern and Western in origin, and was also 'teachable' by textbooks. What is the nature of 'Rika' education? The objectives of 'Rika' in elementary school, according to the Course of Study for Elementary Schools issued in 1891, to accompany the 1890 Elementary School Order, were "to make close observation and experiment with natural things and phenomena and to develop an understanding of their inter-relationships and the relationship with human lives, and to educe (educate) a love of nature (Shizen) in the minds of children". As such, the objectives of 'Rika' have traditionally been stated by the Ministry's regulations since then. The last sentence of the objectives, which is firmly in the affective domain, has existed for more than 120 years. These objectives can be divided into two components; one is a science oriented component and the other is a nature (Shizen) oriented component (e.g., Ogawa 2011). This has been one of the important features of 'Rika' compared with science education in western countries.

36. O6-E3

HPS/NOS IN THE RESEARCH OF SCIENCE EDUCATION IN KOREA: BASED ON THE ANALYSIS OF THE 'JOURNAL OF THE KOREAN ASSOCIATION FOR SCIENCE EDUCATION'

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The recent National Science Curriculum of Korea highlights the promotion of students' scientific literacy, which requires students' understanding of HPS & NOS, for rational and scientific decision making in everyday context. This study is to describe the trend and major findings of science education researches related to HPS & NOS in Korea, and their implications on the practice of science education. The authors reviewed the papers published in the Journal of the Korean Association for Science Education, vol1 - vol30, from 1978 to 2010. We could classify the researches related to HPS & NOS into several categorizes: focusing on the main concepts and issues of HPS & NOS; focusing on the key persons of HPS & NOS and their theory; focusing on the education policy and curriculum related to HPS & NOS; focusing on the views of students and teachers on the things related to HPS & NOS; focusing on the development of the educational program and activities related to HPS & NOS and their influences, and so on. We found also that the frequency and the main issues of these researches have changed according to the change of curriculum, social issue, and so on. Finally, several suggestions for future programmes and researches for promotion of students' understanding of HPS & NOS and scientific literacy will be discussed.

37. O6-E4

REFINING LAKATOSIAN RESEARCH PROGRAM

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In this presentation, I will propose ""Common Cause Argument"" in order to capture the essence of major cases in the history of science. I will make a Lokatosian reconstruction of history of the theory change of Darwin, Newton, and Einstein. I also show that the Common Cause Argument can clarifies Lakatos' hard care and positive heuristics, which has been mystified until now.

- **Oral Presentation 6-F**
- **Date: Friday, October 28, 2011**
- **Time: 13:00 ~ 14:20**
- **Room: #6 (2F)**
- **Chair: Zuway-R Hong (National Sun Yat-sen University, Taiwan)**

38. O6-F1

EFFECTS OF AN INTEGRATED SCIENCE AND SOCIETAL IMPLICATION ON PROMOTING ADOLESCENT'S POSITIVE THINKING AND EMOTIONAL

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The goal of the study was to test the effectiveness of integrating science and societal implication on adolescents' positive thinking and emotional perceptions about learning science. Twenty-five eighth-grade adolescents (9 boys and 16 girls) volunteered to participate in a 12 week intervention and formed the experimental group. Fifty-seven eighth-grade adolescents (30 boys and 27 girls) volunteered to participate as assigned the comparison group. Additionally, 15 experimental students were recruited to be observed and interviewed. Paired t-tests, correlations and analyses of covariance assessed the similarity and differences among groups. The findings were that the experimental group significantly outperformed its counterpart on positive thinking and emotional perceptions and all participants' positive thinking scores were significantly related to their emotional perceptions about learning science. Recommendations for integrating science and societal implication for adolescents are provided.

39. O6-F2

I DO NOT WANT TO BE A PHYSICS TEACHER ANY MORE: SOME PRE-SERVICE TEACHERS' DECISION AFTER WANDERING IN COLLEGE

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In Korea, pre-service students could be the full time public secondary teachers after taking the employment test. However, the test was highly competitive and the success rate was lower than 10 % in average. It meant that most of the graduate students in college of education could not actually be teachers in Korea even though they got the certificates after graduation. The aim of this study was to explore pre-service teachers' idea and hope to become physics teachers after three years college experiences. Participants were fifteen students in fourth grade of college level in Korea and they majored in physics education. Generally, students who were in fourth grade in college of education were supposed to become secondary teachers or regarded as hoping to be secondary teachers. The interview and other records, however, showed that some students changed their mind and they did not want to be physics teachers any more. The major cause of this change was a rare chance to be employed in public or private secondary school and some other reasons were also found. Academically and practically, more attention needed for students' difficulties in their college life.

40. 06-F3

EXPLORING AND COMPARING AUSTRALIAN AND KOREAN STUDENTS' PERCEPTIONS OF SCIENTISTS AND ENGINEERS THROUGH DRAW-A-SCIENTIST AND DRAW-AN-ENGINEER TESTS

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Many research papers on students' images of adult professionals have revealed that there are usually stereotypes and misconceptions in these images. In general terms, it has been argued that such images do influence students' future career choices and attitudes to further study in the corresponding field(s). The most common stereotypes of scientists reported in the literature include scientists being predominantly male, wearing glasses and a white laboratory coat, working very hard and spending little time in family and social activities. Many students also view scientists (and engineers) as extraordinary or mythical people rather than as real people. In this paper, we explored elementary school students' perceptions of scientists and engineers, together with the similarities and differences between them. We also compared these perceptions across Australian and Korean elementary school students. As part of our work, students were asked to draw scientists and engineers at work and to provide explanations for their drawings. The drawings were examined with a checklist adapted from the literature. The stereotypes of scientists included among others the wearing of glasses and lab coat, and those of engineers included an overall in addition to glasses. Results also showed differences on how students perceived scientists and engineers based on nationality and gender. The findings of this study will contribute to the understanding of students' thinking on science and technology education, which is the part of the broader STE(A)M (Science, Technology, Engineering, Art, and Mathematics) education. In addition, teachers could use the results in this study to help their students develop more authentic and positive images of scientists and engineers.

41. 06-F4

CONSTRUCTION OF COMPETENCE INDICATORS OF ENERGY AND CLIMATE CHANGE

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Since 2001, curriculum design in Taiwan has tended to focus on the basic abilities that students can understand and use from what they have learned, which replaces traditional evaluation only involving students' curriculum knowledge. With the help of the construction and interpretation of competence indicators, teachers enable to clearly and concretely construct students' requisite abilities. Therefore, research on construction of competence indicators has played an important role in teaching research and practice. Moreover, the issue of energy and climate change has increasingly been the object of study all over the world in recent years, but there has been still little complete research into its construction and competence indicators. Construction of competence indicators of energy and climate change of this study is expected to assist experts and teachers to apply this issue to their teaching and practice in an attempt to enable younger senior high school students to deeply understand this issue and help them put it in use. This study is based on the previous concept map, along with relevant literature reviews, expert and teacher forums on energy and climate change, and three times implementation process of Delphi Technique. Finally, the important teaching ideas of this issue and appropriate teaching stages (elementary, junior, and senior high school) are found. Besides, competence indicators of this study are divided into cognitive, affective development and psychomotor domain, and each category contains six themes. The followings are the example of competence indicators of cognition: the abilities of having a conception of energy and power; of the knowledge of energy development, consumption, and influence; of the understanding of the cause of climate change; of the knowledge of the phenomenon and impact of climate change; of the capability of mitigation strategy; and of the idea of adaptation strategy. Through these indicators, we hope to offer a complete construction as reference resources and teaching material.

- Poster Exhibition 3-A
- Date: Friday, October 28, 2011
- Time: 11:00 ~ 12:00
- Room: Main Room

1. P3-A1

LEARNING MATH FROM TRAVELLING: MATH WEEKEND CAMP FOR INDIGENOUS CHILDREN

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"Mathematics for all" has been internationally considered to be a key issue of mathematics education (NCTM, 2000). And how to improve indigenous mathematics education through culture and local characteristics is already the primary question among education scholars in many developed countries. The Ministry of Education in Taiwan also highlights the importance that school education should take care of all children in mathematics learning, especially for indigenous students who need special attentions (Ministry of Education, 2003). This case study is a part of a four-year project supported by the National Science Council of Taiwan from 2009 to 2013. The main purpose of this project is to improve the environment of mathematics learning and teaching for an indigenous elementary school in Nan-tou County of Taiwan. The school students mainly come from three different tribes, with a majority being the Sediq people. The focus of this presentation would be on the introduction of how the researcher created mathematics environments for indigenous children through the Math Weekend Camp and what indigenous children learned in the weekend camp. The theme of the camp was "Learning Math from Travelling," because Nan-tou is a very beautiful county in Taiwan and it is worthy to lead indigenous children to know and love the county they lived. Three mathematical activities have been scheduled for the Math Weekend Camp completed at the case school. For the junior grade students, the activity titled "One-day trip in Nan-tou", for the middle grade students, the activity titled "Visiting Nan-tou day-and-night", for the senior grade students, the activity titled "Excellent travellers in Nan-tou". All three activities covered how to organize a wonderful journey in Nan-tou County. The researcher expected the indigenous children could learn mathematics through the arrangement of their journey, like "time", 'distance", "speed", 'location", and "spatial orientation". Each activity of the Math Weekend Camp was videoed and elaborated to be shared. Through observation and analysis of related documents, the researcher gained an insight into the mathematics learning of indigenous students in the case school, the researcher then can try to develop applicable mathematics learning environments and support based on these understanding and findings. Hopefully, once the project has been completed after four years, the place-based mathematics learning environments created for indigenous children would be helpful to enhance the tribal children's mathematics learning.

2. P3-A2

CASES OF THE APPROACHES FROM SCIENCE COMMUNICATION TO SCIENCE EDUCATION IN JAPAN

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Science communication (SC) in Japan have recently expanded and succeeded in enhancing the interaction between citizens and scientists. It is pointed out that there are a variety of attitudes to science among these citizens, and that SC tends to target to the audience who are highly concerned about scientific issues. Assuming that the purpose of SC is to promote greater public engagement in science, SC should target to the people with various level of interest in science. In order to involve those who have a wide range of interests in science into SC, we consider it should be much more encouraged to facilitate exchange and cooperation between SC and formal science education from primary through tertiary level. When designing approaches from SC to formal science education, the following processes could be vital: 1) to develop scientists' ability to explain scientific data and theories as well as citizens' ability to understand them, and 2) to develop the abilities of scientists and citizens to participate in scientific arguments. We view the first process in the above as a key to the approaches to formal science education. The concept of 'critical thinking' could be one of important factors in such approaches. Tohoku Earthquake and Fukushima nuclear plant accidents were opportunities to question the past way of SC in Japan, because the standpoints of Japanese government, Tokyo Electronic Power Company, and scientists who have maintained the government's nuclear energy policy brought a sense of distrust among citizens. It is required to rebuild the role of media between citizens and scientists, to secure the diverse approaches from scientists to citizens and vise versa, and to make it possible for individuals to participate in scientific enterprise. The first author is going to organize a symposium in August 2011, where all the authors will present topics about approaching from SC to formal science education for promoting public engagement in science. Our group consists of researchers in science education, psychology, science journalism, SC and ICT. The topics could be as follows:

1) The role of critical thinking in SC

a) Critical thinking which supports citizens' assessment of information reliability or decision making, b) Development of children's critical thinking through controversial issues, and c) The importance of critical thinking in developing science communicators

2) Mass/personal media which scientists as well as citizens could access and transmit information about science

3) Training for developing scientist's communication skills

4) Making opportunities for scientists to communicate science

5) Use of ICT to support SC activities.

We would like to report on the topics and discussions at the symposium.

3. P3-A3

A STUDY OF 4TH GRADERS' INFORMAL SCIENCE LEARNING AT TAIPEI ZOO

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The major purpose of this study is to investigate the informal science learning for 4th graders at Taipei zoo. There were 332 4th graders at an elementary school in Taipei participated in this study. Science learning activities include classroom discussion on the topics of animals and biodiversity issues, and a one day field trip to the Taipei zoo. The research instruments used in this study were questionnaires of learning at Taipei Zoo, and study sheets. During their visit at the Taipei zoo, pupils were guided by teachers and volunteer parents from each class to act as leader and assistant to enhance pupils' scientific inquiry. Follow-up classroom activity at the post-visit, in addition to continue the discussion of animal themes and biodiversity issues, pupils were asked to fill out the questionnaires of learning at Taipei zoo, and study sheets. The results of the study were summarized as following: 92.2% of pupils satisfied with the field trip to the Taipei zoo, 97.9% of pupils reports having better understanding on animals, 93.7% of pupils reports having better understanding on biodiversity issues, 43.1% of pupils are willing to visit Taipei zoo again in the future, and the most 5 popular animals were panda, penguin, elephant, koala, and tiger. These results indicated that informal science learning at Taipei zoo combined with formal science learning at the classroom has significantly influence on primary school 4th graders.

4. P3-A4

TEACHERS' PERCEPTIONS AND INTERACTIONS CONCERNING A MULTI-DISCIPLINARY INTEGRATED APPROACH TO SCIENCE TEACHING

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The purpose of this study is to examine how integrated multi-discipline science teaching can be achieved by a case study of school teachers. Though the integrated approach to teaching science has a long history, most secondary school teaching is enacted by a discipline-based approach presupposing clear boundaries among subjects. The discipline-based approach easily imparts the structure of knowledge and the hierarchy of concepts, yet hardly provides the authentic and complex nature of science in the real world. To overcome the segmenting of disciplines, a multi-disciplinary approach in science, technology, engineering, and mathematics (STEM) education has been proposed and implemented across the world, particularly in the US. Recently an even more encompassing STEAM (adding arts to STEM) education is under preparation by the Korean government. This study investigates teachers' perception about integrated science education, and interaction between science teachers and other subject teachers through a case study concerning pacesetting schools that try to introduce the integration. Obtaining data from teachers through a semi-structured interview, no significant difference existed between teachers who have and have not experienced the integrated approach in their content knowledge related to other disciplines and in their perception about the nature of science. However, teachers who have experienced integration believe that illustrating to students the application of scientific principles in broad topics can affectively affirm an attitude for science and participation in learning. Moreover, the participants thought that teacher collaboration is crucial for integration and that active discussion in the teacher community facilitates collaboration. We also found significant difference between a conventional and innovative school for an integrated approach; in the latter, school culture promotes teachers' motivation and cooperation, and a school organization system supports new innovation.

5. P3-A5

WHAT YOUNG CHILDREN KNOW ABOUT BATS: A SUMMATIVE EVALUATION OF MUSEUM EDUCATIONAL PROGRAM BY VISITOR STUDY

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Many studies have confirmed that learning happens in museums. However, due to the diversity of situations/variables involved in informal learning, most museum visitor studies have focused on changing attitudes and enhancing interest. In this study, essay writing was used to assess children's learning outcomes of a theme-directed museum educational program. Writing directions were given to help the participants express their own ideas and synthesize information. The subjects of the study were 93 children from different schools enrolled in grade 3 through grade 6 and aged 9 to 11. The subjects were directed to focus on the topic of "The Legend of the Bat", the theme of the exhibition that they visited. Participants were provided with a short preface to "Stellaluna" a children's book written by Janell Cannon. The pre-writing activity involved elements of the exhibition, as well as related content or media, to create the second part of Stellaluna's adventure. The words and phrases used by the children to construct their writings were analyzed. The purpose was to understand which scientific concepts were learned as well as to determine the attitudes of the subjects. Four categories of concepts about bats were identified by three raters. Percentages of agreement for the four categories were 82, 90, 87, and 78 with reliability coefficients ranging from .91 to .96. The children in the theme-directed program had more cognitive development than attitude expression. They interpreted with 87 to 99 percent accuracy the four categories of concepts. Despite fewer expressions in attitude, 91 percent were positive. From the comparison of homogeneity, there was no significant difference between children in grades 5 to 6 and those in grades 3 to 4 which suggests that theme-directed programs in a museum can be applied successfully to learners with a wide age range. However, a remedial follow up activity or program is recommended to help those children with misconceptions to seek clarification. Attention should also be paid to children's anthropomorphic skills in writing to meet the requirements of accuracy in science.

6. P3-A6

THE SURVEY OF ELEMENTARY SCHOOL TEACHERS TOWARD CLIMATE CHANGE ISSUES IN INTERACTIVE MULTIMEDIA SYSTEM - NATIONAL TAIWAN SCIENCE EDUCATION CENTER SCIENCE ACTIVITIES AS EXAMPLE

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This research mainly investigates elementary school teachers' opinions on content related to climate change issues in interactive multimedia system, to be served as reference for the development of related teaching material for informal institutions. These researches consults curriculum outlines and related literature, take students' development, demands, hobby into accounts, emphasizes on feasibility, interesting and humanity contents, designing questionnaires of elementary school teachers toward climate change issues in interactive multimedia system and carry out surveys. The content of questionnaires divides into five aspects: teachers 'opinions toward climate change teaching, the demand of teaching materials related to climate change issues, teaching opinions on interactive system, scientific truth and conflict factors, adjustment and reduction factors. Elementary school teachers are research participants, who are divided into whether they attended environmental related seminars and designed related teaching materials. Teachers are asked about teaching opinions on climate change issues, teaching materials' demand for climate change, different opinions on interactive system, and also examines factors included scientific truth and conflict, adjustment and reduction. Through series of questions, this survey intends to investigate teacher's understanding and teaching demand towards interactive system related to climate change. It is hoped that the results could provide reference for teachers, text book publishers and people who develop relevant teaching material.

7. P3-A7

THE CHANGE IN INQUIRY ABILITIES OF PHYSICALLY CHALLENGED STUDENTS BY SCIENCE CLASS BASED ON POE APPROACH IN INFORMAL EDUCATION ENVIRONMENT

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Since the 1980s, 'science for all' emerged as an important theme in science education, but the students with disabilities have been difficult to access science activities and alienated from science education without engaging research work. Scientific inquiry skills are important for all students regardless of disability in everyday life as well as in learning science. In this study, the changes in inquiry skills of three middle school students of disabilities after science class by twelve times based on POE approach were analyzed. 'Scientific inquiry skills test tools' by Kwon and Kim(1994) was used and analysed. As a result, the science inquiry skills of physically challenged students advanced in general. Especially, observation skill among the basic inquiry area and controlling variables skill among the integrated inquiry area are advanced.

8. P3-A8

PERCEPTIONS OF TEACHERS AND THE EFFECTIVENESS OF PBL PROGRAMS USING THE SCIENCE MUSEUM.

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The purpose of this study were to analyse teachers' perceptions about instruction using science museum, and to find out the effectiveness of PBL(problem based learning) programs in science museum. In this study, 40 elementary school teachers were participated and after teachers' professional development in science museum especially PBL programs, they were investigated teachers' experiences in teaching with the science museum as well as their confidence, their perceptions, educational needs, and their willingness to practice the instructions using science museum. The results are as follow: many teachers were also found to have confidence in teaching with the science museum.

9. P3-A9

EXPLORING FACTORS INFLUENCING DOCENTS' THEORY AND PRACTICE

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To meet the goal of scientific literacy, there has been emphasis of science learning beyond classroom at informal learning setting like science center recently. We have 'docents' or 'science interpreters' who interact directly with visitors or students who visit science centers. Docents' roles are supposed to interact with visitors to help them understand science concepts at science center. While there had been many recruited docents or science interpreter regularly in Korea, few had reported how docents/science interpreters' theories and practices can be professional to produce the most effective science learning in science center. For docents' profession, there need to be different PK, CK, PCK, and even understandings about science learning at science center when compared to those of teachers in science classroom. This study was to find out factors influencing docents' theories and practices of science teaching at informal setting. For theories, 57 docents participated in filling out the questionnaire developed by the research team and responded it in terms of their motivation, roles, values , reward, and expectation of 'doing' docents at science center. For practices, the emerging patterns of interacting with visitors or students were developed according to the working career as preservice, novice, and experience docents. Factors for docents' struggling to survive to be professional were released in ways of pivotal and interfering ones. The appropriate and ideal docent preparation program and professional program were suggested to enhancing science education of informal learning.

10. P3-A10

HOW EVOLUTION WAS TAUGHT IN JAPANESE SECONDARY SCHOOLS BEFORE WORLD WAR II

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There were many previous studies on evolution in Japan before WWII. Almost of those previous studies focused on the introduction of evolution into the Japanese society, and they concluded that evolution was introduced by means of the social evolutionism. On the other hand, a few studies focused on the teaching evolution in Japan before WWII. One study analyzed the contents of evolution in secondary biology textbooks with the viewpoint of the nation's ideology. It concluded that evolution in those textbooks had been presented in various ways with influence of the nation's ideology. We consider that it is important to review the history of teaching evolution before WWII. A knowledge from historical research can provide a perspective for decision making about educational programs and it assists in understanding why things are as they are (William & Stephen 2005). Findings of the traditional teaching evolution in Japan will be able to contribute to consider the teaching evolution in secondary schools both present and in the future. The purpose of this study is to review the history of teaching evolution in the old secondary schools. We set out the following analysis points; (1) What ideas did authors have in organizing biology textbooks? (2) What were the criteria for ordering the contents in those textbooks? (3) What contents on evolution were dealt in those textbooks?

We have analyzed secondary biology textbooks published from 1886 to 1945 and academic papers written by those textbooks' authors. In summary, we find out that some textbooks' authors intended students to recognize the place of humans in nature rather than to understand the nature of scientific theory, from the viewpoint of evolution. We also find out four features about the contents of evolution in textbooks. Firstly the contents of evolution in textbooks were taxonomical and descriptive. Secondly the contents of evolution were tended to assign in the late in textbooks and they were presented as one of the outline of the living things. Thirdly the contents of evolution were mainly constructed by two components; one was to describe the facts that evolution had occurred, and another was to explain how evolution had occurred. Fourthly there were some doubts about the reliability of the explanation on the process of evolution in textbooks. Eventually the contents to explain how evolution occurred were deleted and at last the contents to describe the facts of evolution were only remained in textbooks.

11. P3-A11

THE SCIENTIFIC IMAGINATION APPEARED IN RESEARCH PROCESSES KOREAN SCIENTISTS

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Imagination plays an important role in scientists' discoveries and their most famous breakthroughs. The purpose of this research is to describe the imagination of scientists and find the characteristics of scientific imagination. For this purpose, we interviewed eight Korean scientists who have more than twenty years of research experience and explored how imagination influences their research process. We shared each scientist's experiences of their scientific research and figured out overall characteristics of scientists' imagination. Semi-structured interview protocols were used, and all interviews were recorded and transcribed. Data were analyzed using an inductive approach derived from grounded theory to identify emergent themes. From the interview, we found three themes of scientists' imagination: curiosity, divergent thinking and wealth experiences. These imaginations play an important role in their scientific investigation. Finally, we found two characteristic of scientific imagination: The relationship between scientific knowledge and imagination and productivity aspect. These findings would be a four stepping stones for science educators to understand imagination in science and make science classroom more creative.

12. P3-A12

A COMPARATIVE STUDY OF MIDDLE SCHOOL STUDENTS' IMAGES AND PERCEPTIONS OF SCIENTISTS, TECHNICIANS AND ENGINEERS

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The purpose of the study was to analyse middle school students' images and perceptions about scientists, technicians and engineers. Fralick *et al*.(2009)'s "Draw a scientist at work and draw an engineer at work" was modified and administered to 110 middle school 3rd grade students from 5 middle schools in Busan. The results of this study were as follows. First, the representative image of the scientist was the man with glasses and lab gown performing the chemical experiment. There were no significant differences between the boy students and girl students in terms of the scientist images. Second, the representative image of the technician was the man who was fixing a car and working with his hands. The technicians were illustrated as working with tools like wrenches, hammers and so on. There were no significant differences between the perceptions of boy students and girl students in terms of the technician images. Third, the students involved in this study frequently perceived male engineers as working indoors. But perceptions about performance of engineers were significantly different between boy students and girl students. A majority of boy students recognized that engineers should design, invent and create the products, however many girl students perceived the engineers as car mechanics. Fourth, the students perceived differently scientists' task compared with technician's, but they had a difficulty in distinguishing the scientists' task from the engineers' task.

13. P3-A13

PRE-SERVICE SCIENCE TEACHERS' CONCEPTIONS OF THE NATURE OF SCIENCE

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This study aimed to assess pre-service science teachers' conceptions of the nature of science and whether these conceptions were related to there disciplinary background as well as gender. At the beginning of the spring semester in March, 2011, 71 undergraduates (43 freshmen and 28 sophomores) at science teacher education programs responded to an NOS instrument (Cobern & Loving, 1998) of 40 items divided into six categories. The six categories are as follows: Theoretical emphasis means that science is primarily a rationalistic, theory-driven endeavor; Empirical emphasis represents that science involves data-gathering and experimental work in pursuit of physical evidence; Anti-science view explains that science is overrated and one should not give much credence to the aims, methods, or results of science; Scientism means science the perfect discipline, the highest form of knowing; Cultural view explains that science is embedded in our culture, which provides a social, historical, and psychological background to scientists' work; and finally, balanced view means that science is complicated affair, there is no single scientific method, science cannot be reduced to a few simple descriptive statements. There were significant differences among different disciplines of science background. For the view of empirical emphasis, students of biology education showed significantly (F=2.585; p=.060) higher (M=3.71; SD=.40) that students of physics education (M=3.36; SD=.35), while there were no differences in the rest five categories among four different science discipline areas. Although significant (p<.05) difference was not found for gender, male students tended to display higher scores in theoretical emphasis and cultural view and the opposite was true for the rest four categories.

14. P3-A14

THE EFFECTIVENESS OF USING ABIM (ARGUMENT-BASED INQUIRY MODEL) FOR SCIENTIFIC LITERACY IN THE CLASSROOM

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The goal of science education is scientific literacy, which means that general citizen can understand scientific issues which they encounter in daily life and make decision its right or wrong. To meet this goal of scientific literacy, teachers need to implement scientific inquiry through which students have chances to learn scientific concepts, inquiry skills such as procedural as well as scientific thinking, experience attitude about science as well as NOS (Nature of Science), and understand the relationship among STS (Science-Technology-Society). However, students do not have those all chances to experience authentic scientific inquiry envisioned in Standards (2000). The researchers developed Argument-Based Inquiry Model (ABIM) where students have OTL (Opportunity To Learn) scientific thinking process; that is, OTL how to frame questions, how to collect data, how to form explanation, how to evaluate explanation, and how to present it with justification. The research context is that Kim (Teacher) implemented scientific inquiry activity of "heat transfer" with the period of 3 blocks. Eight students at high school level participated in this study with teacher guidance. The results were as follows. Successful critical incident case is that students were very active in framing questions, making hypothesis with creative ideas and collecting data responding to challenging task, which made students challenged to provide creative ideas. Unsuccessful critical incident case is that students in groups tended to follow one targeted student's decision in forming explanation and evaluating it, proving that students had not been exposed to the context where they develop arguments and refute them through argumentation. Therefore, students had tendency of avoiding expressing their opinions freely even though they had their own different or alternative opinions. To make ABIM effective teaching model in inquiry classroom, more structured teachers' roles of scaffolding were expected as follows; develop challenging tasks promoting student's creative ideas, encouraging students' discussion with supportive and refute evidence, facilitating students' discussion not to be limiting to a few targeted students, and providing students pre-planned brief instruction to experience the nature of science and philosophy of science which through students need to be ready for developing argumentation and attitudes about science. On the basis of these suggested components, more structured ABIM was explored with the same task but different group of students.

15. P3-A15

ANALYSIS OF THE CORRELATION BETWEEN CLASSIFICATION ABILITY QUOTIENT AND CORTISOL-HORMONAL CHANGE IN MIDDLE SCHOOL STUDENTS

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The purpose of this study is to investigate the relation between the classificational ability quotient and cortisol-hormonal change in middle school students. To this end, biological classificational activity which students could experience an integrated science process from observation to generalization in classifying 20 other types of feathers(different shape, size and color) was developed by a biology education professional and two current teachers through seminars. The subjects of this study were 33 second-year middle school students in Seoul who don't have any problem to measure hormonal change. The subjects performed operational classificational activity by individuals in an open and autonomous environment. Then each of their 2mL saliva samples were extracted before and after the task so as to measure the amount of the variation in concentrations of cortisol hormone. The classificational ability quotient were calculated by applying subjects' result of classificational activity paper to classificational ability quotient equation. In order to figure out the relationship between the classificational ability quotient and the amount of cortisol hormone excreted, pearson correlation analysis was performed. The main interest of this study is to investigate learner's classificational ability from the point of view of physiological changes. The main results are as follows: First, the classification methods of students were mostly non-hierarchy, one-dimensional simple classification, and making two groups with one classificational criteria. Second, the amount of learner's cortisol hormone decreased in overall after the free classification(before task : 17.3±7.55nm, after task : 14.9±5.20nm). Besides, who had high variation figure in concentrations of cortisol hormone after task indicated high classificational ability. Third, the case of the students whose amount of saliva cortisol hormone decreased after activity, who had less variation showed higher classificational ability quotient. In other words, there are positive correlation between induced secretion of appropriate amount of the cortisol hormone in the saliva and classificational ability(r2=.192, p<0.001). This study suggests that it needs to understand the current level of middle school students' fulfill in classificational task, and to develop appropriate classificational task considering the physiological changes that occur to the learners during classification learning.

16. P3-A16

EFFECTS OF CONCEPT MAP STRATEGY ON GLOBAL WARMING AND CLIMATE CHANGE COURSE

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Over the last few decades, a concept map(CM) is regarded as an useful and promising tool for science education research on students' understanding of concepts. Features of a concept map are: concepts are represented in a hierarchical structure and in graph to show the relationships between concepts. Also, global warming and climate change are essential environmental issues that researchers are concerned about in science education. Therefore, educating students to enhance their respect and understanding of these issues is important. Because of the concepts about these scientific issues are complicated, CM may be a potentially useful strategy to improve students' achievement in learning these issues. Related research has been conducted to investigate effects of concept map teaching strategy on students' learning achievement . However, little research has been done on different structures of CM that have different impacts on students'learning achievement. Thus, this study has examined whether CM can be used to help students to improve their learning achievement in global warming and climate change course and whether different structures of CM have different impacts on students'learning achievement of scientific concepts. The study has been conducted with"quasi-experiment"design. The participants were 74 students from three sixth grade classes in an elementary school in Taiwan. The participants are divided into three groups (concept map (CM) versus traditional textbook exercises (TTE) versus control group (CP)).The CM group utilized concept maps in teaching and learning, while the TTE group maintained normal traditional curriculum. Students in the CM and TTE group went through the 280-min global warming and climate change course for 4 weeks, while those in the control group did not experience any experimental training. Furthermore, this study uses three different structures of concept map in teaching. Examples, Flowchart, and Casual relationship are the three types of concept maps based on the unit topic. The tools used for this study are the Global Warming and Climate Change Achievement Test and the Attitude toward CM Inventory. The collected data were analyzed with one-way ANCOVA and descriptive statistics . The result shows that students in concept map (CM) and traditional textbook exercises (TTE) group have better learning achievement performances on global warming and climate change courses than students in control group. In addition, the result shows that using a Casual relationship type of CM has better impact on students' scientific concept learning. Finally, most of the students were satisfied with using CM to learn the concepts of global warming and climate change. Over all, the results could be useful to teachers who plan curriculum and design instruction in these scientific issues.

- **Poster Exhibition 3-B**
- **Date: Friday, October 28, 2011**
- **Time: 11:00 ~ 12:00**
- **Room: Main Room**

17. P3-B1

THE TEACHER'S PERCEPTION ABOUT THE NATURE OF SCIENCE INVOLVED IN SCIENCE CURRICULUM

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Many science educators have made an effort to improve the students' scientific literacy in the preparation for the rapid social change. For this, science educators have emphasized the understanding about the nature of science and they have regarded it as the most important factor to be a person with scientific literacy(Abd-El-Khalick & Lederman, 2000; Lederman, 1992; Meichtry, 1992; NRC, 1996; Osboren et al., 2003).

Many studies have shown so far that teacher's understanding about the nature of science may have an effect on students or may not in their classes(Collete & Chiappetta, 1984; Lantz & Kass, 1987; Zeidler & Lederman, 1989). However, according to the research concerning the PCK(pedagogical content knowledge), the teacher's scientific knowledge, belief and perception are mirrored to their science classes. If teachers perceive about the nature of science reflected in science curriculum, they just teach as the science classes have nothing to do with their understanding of the nature of science. They would just teach depending on the science curriculum. Recently, our national curriculum has been revised several times. Whenever science educators revised the curriculum, they have reflected the nature of science in the science curriculum. Unfortunately, though, we cannot make sure how many science teachers perceive about the nature of science presented in the science curriculum. In this study, we investigated whether science teachers in secondary schools recognize about the nature of science reflected in science curriculum or not when they teach students science. We also investigated what teachers think the nature of science is. The research was performed through interviews with science teachers in secondary schools and the results are as follows. First, it was checked that none of the subjects perceived about the nature of science presented in the science curriculum while teaching students. Second, many of them knew that the nature of science had been introduced to the 6th or 7th science curriculum for the first time. Third, most of the subjects viewed the nature of science as a similar concept with science inquiry.

18. P3-B2

STUDENTS' AND TEACHERS' RECOGNITION OF ILLUSTRATION IN PHYSICS / TEXTBOOKS BASED ON THE REVISED NATIONAL CURRICULUM IN 2009 AND ADVANCING PHYSICS OF UK: FOCUSING ON INFORMATION AND COMMUNICATION UNIT

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Students recognize illustrations before letters when they look at textbooks. Students find some illustrations difficult to understand, not because there is something wrong with the illustration itself but because information has not been provided or presented in an effective way. For this reason, Illustrations are very important for students to build up the concepts of what they are learning. For the purpose of the study, we have made 12 questions with selected 9 illustrations included in Information and Communication unit of the Physics Ⅰ textbooks according to the revised national curriculum in 2009 and Advancing Physics of UK and then we conducted a survey with 360 students of high school and 22 teachers of science. This study intends to recognition the contents of physics Ⅰ textbooks, focusing on the chapter of Information and Communication. For this, a questionnaire on the three types of illustrations was prepared to find out what kind of illustration students thought was easy to understand and why they chose it. Based on the answers to the questionnaire, the conditions for clear and effective communication of textbook information through illustrations were found, by analyzing the advantages and disadvantages of some types of illustrations. In this study, illustrations students thought difficult were picked out be easier and clearer to understand to see which of them are more helpful for students. The features of illustrations easy for students to understand well are as follows:
First, the essence of improving illustrations is that the contents should be concise and brief in order not to confuse students. The the illustration should also include each step of the process through which the result was achieved, instead of simply showing the result. Second, the illustration should not be difficult to externally visible: When high school students feel frustrated while trying to understand the illustration, they tend to give up rather than ponder more to get to the meaning. Third, no matter how difficult illustrations are, some good clues and explanations about them make students try to understand what they mean positively rather than lose interest. This study might help to improve the illustrations in the high school physics textbooks.

19. P3-B3

MICROORGANISMS LIVING INSIDE HERMETIA ILLUCENS'S INTESTINE AS A SOLUTION OF REDUCING ORGANIC WASTE

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Since Hermetia illucens, known as the black soldier fly, has shown its great ability to digest organic waste, it considers as being an eco-friendly manner to reduce the amount of food-related pollution and produce energy from biomass. As high microbial diversity was found within its intestine, we hypothesized that intestinal microorganisms could play an essential role in decomposing organic wastes. Larvae of H. illucens were raised in different nutrient sources; carbohydrate, lipid, protein and mixture of all three as a control. Microorganisms with decomposing enzyme activity were screened and highly efficient bacteria were selected. To understand dynamics of microorganism inside the larva, total metagenomic DNA was obtained from each intestine of larva which was grown in different nutrient sources and different stages. Partial bacterial rRNA gene was amplified with fluorescently labeled primers and PCR products were digested with selected restriction enzymes, AluI and MspI. The microorganism' population was analyzed using Terminal restriction fragment length polymorphism (T-RFLP). As results, the similarity index and Shannon diversity showed that there was structural shift of bacterial population according to nutrition consumed and growth stages. The relationship between the growth rate of larva and its bacterial diversity indicates the important role of its intestinal microorganisms in H. illucens, inferring its food decomposing ability due to their intestinal microorganisms. These intestinal microorganisms of H. illucens could be a useful biological resource for more efficient waste management in the future. This is how students explored authentic scientific inquiry at real context of inquiry. Students will share what they felt in terms of inquiry and nature of science.

20. P3-B4

A CASE STUDY ON INSTRUCTIONAL DESIGN PROCESS FOR INTEGRATED SCIENCE LESSON BY SECONDARY SCIENCE TEACHERS: FOCUSED ON THE CONSULTING OF 5-STEP'S INSTRUCTIONAL DESIGN FOR INTEGRATED SCIENCE LESSON

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The purpose of this study is to analyze secondary science teacher's planning process for integrated science lesson. For the study, the relevant reference was collected from various sources, including literatures, previous studies regarding integrated science education and individual studies. Two teachers (one from middle school and the other from high school) participated in the study. In this study, 'the 5-step's instructional design' was adopted from the former studies. The teachers were asked to develop an instructional plan based on 'the design' provided with. 'The five-step instructional design' contained the analysis of the curriculum; teaching structure; the design of learning activities; development of lesson plan for every hours; development of teaching and learning plan. At each stage of the design, any difficulties and/or doubtful points pointed out by the teachers were recorded. The records were then discussed with researchers, and subsequently three-way consultation which links researchers, teachers, and assistant teachers was formed. While the consultations provided a framework for an instructional plan, the teachers were asked to take a leading role in terms of selecting the chapter to be taught; analyzing the course structure; and making detailed teaching plan. In the course of consultations, discussion, records, and analysis were organized into a journal. Based on the journal, the aspects of the planning process, including difficulties and problems faced by teachers, were analyzed in-depth. From the study, it could be observed that both high school and middle school teachers faced various difficulties in preparing for the integrated science lesson. Among other things, the teachers emphasized the difficulties in the stages of selecting the topic, collecting the relevant information, and restructuring and organizing the lecture contents. In the study, the middle school teacher recognized the importance of the 'integration' of the course structures. The teacher believed that, unlike normal classes, understanding the whole process of designing course structures by clarifying the goal and objectives of the class and extracting the key words from the contents was critical in the integrated science education. The high-school teacher, on the other hand, found it quite difficult to clearly understand the concept of integrated science due to his adherence to the meaning of 'integration' of his own. As such, the high school teacher required more frequent consultations in developing 'the 5-step's instructional design'. Through the study, we could identify the difficulties faced by the two teachers in developing an instruction plan for the integrated science lesson. In addition, we could observe how teachers cope with those difficulties through discussion and consultations.

21. P3-B5

THE UNDERSTANDING AND LEARNING SURVEY OF ELEMENTARY SCHOOL STUDENTS TOWARD CLIMATE CHANGE RELATED FACILITIES

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This research aims at investigating the understanding and learning status of elementary schools' students toward counter climate change facilities. This research focuses on questionnaire survey, a total of 350 elementary school students from north Taiwan elementary schools, and examines in depth the usage of learning environment based on facilities by different teachers for climate change issue, and the frequency of utilizing facilities of different students from different grades and schools, and also look into students' demand from schools' resources, teachers' activities, and examining their opinions on the learning and opinions on energy efficiency and carbon reduction related issues. The findings of research are as following: **1.** On the aspect of schools, when asked about the opinions of utilizing facilities included energy efficient air-conditioner, composting facilities, water efficient toilet, water efficient faucets and the reduction of garbage to undergo the learning of energy efficiency. **2.** On the aspect of grades among these schools, we analyzed these schools facilities by different students. And we found grade 5 students like the teaching method of role play, while grade 6 students like to join outings, arts competition and display, hands-on operation, and other integration into teaching. **3.** We analyzed these students regard as important to undergo learning by different schools. Top facilities of students regard as important to undergo learning, were recycling gadgets, classroom ventilation facilities, water efficient toilet or water efficient faucets. **4.** We analyzed these students' opinions on the importance of environment issues and related activities by different schools. Top priorities of students' opinions on the importance of environment issues and related activities, are global warming and strategies.

We understand teachers play important role in providing students' energy efficiency related information. Teachers also are the key person in sustainable campus.

22. P3-B6

THE EFFECTS OF ENGLISH PARTIAL IMMERSION SCIENCE CLASSES ON MIDDLE SCHOOL STUDENTS' SCIENCE ACHIEVEMENT

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The purpose of this study was to examine the effects of English partial immersion science classes on middle school students' science achievements. For this purpose, first year students from the international middle school were divided into an experimental group and a control group. It was also verified that the students in both groups had the same cognitive and English abilities. With the experimental group, English partial immersion science classes using both English and Korean were carried out while with the control group, the science classes were carried out only in Korean. The results showed that there was no substantial difference between the two groups in terms of their science achievements, but both groups scored lower in the science achievements presented in English as compared to the science achievements presented in Korean and the difference between the two groups were again, not significant. From this, it was determined that English partial immersion science classes do not have a substantial effect on science achievements. However, the analysis of science achievements in both languages showed that even with the same science questions, students scored lower on the questions written in English compared to the ones in Korean and the English partial immersion science classes did not have a significant effect on reducing those differences. In the experimental group where the English partial immersion science classes were carried out, it was shown that there was no correlation between English achievements and the science achievements presented in Korean, but there was a direct correlation between English achievements and the science achievements presented in English. On the other hand, in the control group where the science classes were only carried out in Korean, not only was there no correlation between English achievements and science achievements presented in Korean, but there was also no correlation between English achievements and science achievements presented in English. This suggests that despite the fact that these students are international middle school students with higher English aptitudes than other students from regular middle schools, if science achievement questions are presented in English after English partial immersion science classes are carried out, the rankings of science achievements presented in English can be changed depending on the students' English achievement levels. On the other hand, for the students who went through regular science classes, even when the science achievement questions were presented in English, science achievement rankings were not changed based on the English achievement rankings. This is a detail that must be taken into careful consideration when building an evaluation system for English immersion education. Since this study was carried out with international middle school students as

subjects, it is necessary to expand the scope of this study to immersion classes in regular middle school in order to make a comparison.

23. P3-B7

A STUDY ON THE FEATURES OF GUDULJANG USED FOR KOREAN HEATING SYSTEM (ONDOL)

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Gudul is a traditional heating system which was created by our ancestors. This study is focused to the developments of new flooring material through the physical and chemical analyses on the rocks used as Gudul. The study proceeded with selecting the theme and study areas, sampling, geological survey, several analyses of the rocks, and developments of new floor material (a kind of porcelain). Gudul rocks were sampled from a total of twenty one cities and counties, and the rocks were assigned to nine tuffs, five quartz porphyries, four gneisses and three schists in rock type. From the geological study, these rocks are very similar to ones in surrounding areas. Comparing Gudul rocks to others not used in Ondol, the rocks show low densities, higher porosities and brittle features. Analyzed in thermal properties, the rocks are lower in conductivity but higher in conservation and resistance in the aspects of the properties. Considering mutual relations between thermal properties and chemistries of the rocks, conservative characteristics are proportional to MgO contents but not to SiO2. In particular, minute quartz grains in the rocks were gradually cracked and rejected under strong torch flames. Those features may indicate that quartz grains are closely related with the thermal characteristics of the rocks. On the basis of above rock characteristics, new flooring material was made. The material includes the mixed states of amphibolite sludges with high MgO contents and white china soils (bearing kaolinte). Then, the material was tested in the above thermal properties under the variable mixed ratios. At the results, 4:6 (sludge:soil) ratio was the most excellent among above tested materials. So, the textiles were used to make architecture materials and the electric heating cushion, and mug cups were produced as test goods.

24. P3-B8

INFLUENCE ON COGNITIVE LEVEL DEVELOPMENT THROUGH STUDENT-STUDENT INTERACTION IN THE VARIABLE-CONTROLLING ACTIVITIES

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In this study, we analyzed the characteristics of verbal interaction between students and students in the variable-controlling activities of the overall 'Thinking Science' activities, and investigated influence on the cognitive level development due to student-student interactions of the 1st grade middle school students. It carried out the tests of SRT Ⅲ as pre-test, and SRT Ⅶ as post-test in order to identify changes in cognitive level. For data analysis, the subjects were divided into two groups based on the results of pre and post tests: the two groups are the cognitive level improved students group and the stagnant students group. Transcription of the classes in variable-controlling activities was analyzed as the frequency of detailed categories using the analytical framework of student-student interaction. Most of student-student interactions occurred in the stage of construction zone activity. As a result of analysis in the cognitive aspects, the frequency of high level interactions in the improved students group was increased gradually as activities were progressed, and their frequency was more than stagnant students group. These results mean that the students' cognitive level was developing in the mid and late activities compared to the initial activities. It was shown that the frequency of the low level interaction tended to decrease gradually as activities progress. The cognitive level stagnant students did not show a consistent trend both of the high and low level interaction. As a result of analysis in the affective aspects, the cognitive level stagnant students in the positive case were more frequent than the improved students, while in the negative case, the improved students were more frequent.

25. P3-B9

LABORATORY SAFETY SIGNS AND SYMBOLS FOR SCIENCE EXPERIMENTS

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All students can and should learn science by conducting laboratory activities and investigations. Lab safety is of great concern for students and teachers. Recent science textbooks are using some science lab safety signs and symbols for educating students about lab safety. However, the signs and symbols are different from one textbook to another. It could potentially confuse students when they see signs and symbols they are not familiar with. The purpose of this study is to standardize science lab safety signs and symbols. We developed 54 science lab safety signs by analyzing safety concerns of lab activities in science lab books, studying safety signs globally used, and through literature reviews. There are four areas of science lab safety signs: caution, prohibition, direction, and others. The colors of background are yellow for caution, red with diagonal for prohibition, blue for direction and green for others. The science lab safety signs will help students follow the safety precautions expected of them during laboratory.

26. P3-B10

EFFECT OF ATMOSPHERIC PRESSURE

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The subject matter of this class is the effect of atmospheric pressure. Instructional objectives is understanding that we are always influenced by atmospheric pressure in their life. The teaching process is learning research group activities. Process of experimentation are as follows: ❶ dent the aluminum can with atmospheric pressure; ❷ dent the plastic container; ❸ let students realize the magnitude of atmospheric pressure; ❹ ask "why we cannot feel the power of atmospheric pressure"; ❺ and last, let students find examples in everyday life. This can make students understand the concept of atmospheric pressure.

27. P3-B11

EXPLORING THE INFLUENCE OF ONLINE METACOGNITIVE SCAFFOLDING ON SCIENCE INQUIRY

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The purpose of this study is to explore the effects of online metacognitive scaffolding on scientific inquiry. Promoting students' inquiry abilities is considered as the main purpose of science education. However, inquiry learning can be a confusing and complex process for learners. Some research has indicated that learners have certain difficulties in investigation complex topics when they are in hypermedia or technology embedded environments. Students' lack metacognition during their learning process could cause such difficulties. Therefore, the inquiry-based online curriculum with scaffolding has been developed to investigate the impact of metacognitive scaffolding on students' inquiry abilities. Two classes include 51 ninth graders students were chosen from a junior high school at Kaohsiung City as the participants. In a mixed method, the experimental group (26) receiving inquiry-based online curriculum with metacognitive scaffolding was compared with the comparison group (25) receiving the same inquiry-based online curriculum but no metacognitive scaffolding. Research instruments include a test of inquiry abilities, a questionnaire of metacognition, worksheets and computer log files. The results showed that metacognitive scaffolding had a significant impact on students' inquiry abilities learning especially in planning ability. Also, low metacognition students' inquiry abilities were improved and closer to high metacognition students' after the invention. This meant that low metacognition students gained more benefits from the inquiry-based online curriculum with metacognitive scaffolding than high metacognition students did. The results from case analyses showed that students could perform self-monitor strategies after they received a series of certain metacognitive scaffolding. It is suggested the curriculum need to provide metacognitive scaffolding in several inquiry cycles to evoke and promote students' metacognition and inquiry abilities.

28. P3-B12

ELEMENTARY AND MIDDLE SCHOOL SCIENCE TEXTBOOKS PRESENTATION OF ENERGY CONSERVATION AND CARBON REDUCTION IN TAIWAN

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The purpose of this study is to examine concepts presented in elementary and middle school science textbooks in Taiwan. This study employed methods of content analysis to review the conceptions of energy conservation and carbon reduction in the science textbooks. To study concepts presented in the different educational levels and science textbooks, three versions of science textbooks selected were evaluated according to expert's concept maps, including 69 classified main concepts. The main concepts in expert's concept maps were classified with appropriate educational levels (elementary or middle school) by 57 science education teachers and experts. Two major areas of concern are: (1) the correctness of the classified concepts presented in textbooks by different educational levels, and (2) the sequence of the concepts presented in textbooks by different educational levels and grades.

The analysis showed that three versions of science textbooks presented higher correctness of the main concepts in the elementary school level than in the middle school level. A sequence was also found between different grades; for instance, concepts related to energy in one version of three textbooks start introducing to types of energy in the elementary school level, complex types of energy latter, and then more applied example of energy presented in middle school level. Both correctness and sequences of the representation of the sixty-nine main concepts across the three versions of textbooks and different educational levels were revealed and compared. The possible reasons for the sequence and especially for the differences were explored. Suggestions to revise the representation of energy conservation and carbon reduction in science textbooks were provided at the end of the study.

29. P3-B13

UPPER OCEAN RESPONSES TO TYPHOON ABBY IN THE NORTHWESTERN PACIFIC USING A THREE-DIMENSIONAL PRIMITIVE EQUATION NUMERICAL MODEL

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A three-dimensional primitive equation model (POM) is implemented to investigate temporal and spatial variations of temperature with the passage of Typhoon Abby in the northwestern Pacific, August in 1983. The model, which covers most of the northwestern Pacific (24°N to 52°N), simulated Typhoon Abby over the tropical Pacific, and successfully reproduces many observed features, including the pattern of SST decrease, inertial oscillations, etc. In particular, a long persistence of the observed sea surface cooling in terms of several ten days after passing of Typhoon Abby is well represented in the model, suggesting that a cyclonic eddy with a radius of a few hundred kilometers that trailed Typhoon Abby plays an important role in SSC. The model also suggests that a basin-scale temperature variation below the upper layer may be primarily governed by a linear-thermal relation.

Friday, 28

30. P3-B14

SCIENCE AND MATHEMATICS MAJOR PROGRAM (SMMP) IN UPPER-SECONDARY SCHOOLS IN JAPAN: A CRITICAL ANALYSIS OF THE STATUS QUO

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Super Science High School (SSH) program in Japan, which was launched in 2002, has been well-known among East-Asian science educators. At present, 125 SSHs are celebrating rich funding from the government agency (JST) and trying to implement various kinds of activities encouraging their students' positive attitudes and motivation toward science, and their engagement with science learning. The SSH program is managed under a project-based competitive funding scheme. Upper-secondary schools wanting to get the status of SSH need to apply for the program, and once successful, the schools can launch their own program for 3 to 5 years. However, in Japan, another officially institutionalized 'Science and Mathematics Major Program (SMMP)' system has been running in upper-secondary schools along with 'General Program,' an popular academic oriented program whose graduates are mainly expected to go into university programs. The system was developed in 1968 by the Ministry of Education, under the strong pressures from industrial and economic sectors that even upper-secondary schools should be responsible to cultivate capable (middle level) manpower in science and technology related fields, responding to rapid development in science and technology at that time. The first year, total 29 schools accepted to develop SMMP, and after about 40 years, total 185 schools are maintaining the SMMP as one of their official programs. The most important difference between SMMP and SSH is that the former is a permanent program while the latter is a temporal (several years' project based) program. And the program budget for the SMMP is quite smaller than that of the SSH program. Of course, schools with SMMP have chances to apply for the SSH programs and in fact there are many schools with SMMP successfully got funding. One of the key questions is that why does not Ministry of Education directly support the officially institutionalized SMMP? Unfortunately, literature review uncovered that there existed neither historical studies on SMMP, nor comprehensive survey reports on SMMP. Before answering the question directly, we need to know in advance; (1) status quo of current SMMPs, (2) historical background of the development of SMMP, and (3) historical development of SMMP. The present paper, thus, explores mainly the status quo of current SMMPs. For that purpose, the author, in collaboration with the Association of the Principals of SMMP, administered a comprehensive questionnaire on the status quo of SMMP to all of the SMMP (total 185 schools). The findings indicated that the SMMP was under several serious crises in terms of students' recruitment, students' lower motivation toward science and mathematics, entrance exams, relationship between SMMP and General Program within the respective schools, teachers' motivation, financial support, and significant differences in various aspects between SMMP with and without getting fund from SSH programs etc. Some findings from historical development of SMMP are integrated with the survey findings. And preferable futures of SMMP will be discussed extensively.

31. P3-B15

THE DIRECTION OF THE TEACHER'S COLLEGE AND THE IDENTITY OF CHEMISTRY EDUCATION EXAMINED BY ANALYZING STUDENTS'S PATHS IN LIFE AND COLLEGE PLANS

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In this study, we examined the identity of chemistry education in teacher's college by analyzing students's paths in life and college plans. We let students make their roadmaps and analyzed them using the SPSS 18 program. There were significant differences by gender in their paths in life, learning English, travel and volunteer activity. Female students for passing the MEET(Medical Education Eligibility Test) or DEET(Dental Education Eligibility Test) were more interested in learning English and travel than male students. In addition, female students were more interested in volunteer activity. Meanwhile both genders were not interested enough in volunteer activity. And the lower year students, the more interested in medical paths, learning English, travel, grades management, student exchange program and scholarship. On the other hand the higher year students, the more interested in volunteer activity, group study or studying via internet. Then significant differences were in learning English, travel and grades management by students's paths in life. Students who wish to pass the MEET or DEET were more interested in learning English and grades management. Those two factors were essential in passing the MEET or DEET. Students who did not specified their paths had more travel plans than other students for setting their directions of careers. These results show that freshman and female students don't recognize the identity of teacher's college correctly. Because of reduction in the number of teacher recruitment according to decrease of students by birth rate drop, students in teacher's college are expected to continue like this trend that students look for other paths. Therefore, it is required career counseling and guidance for students who give priority practical path choices and college plans over original characteristics of teacher's college. And it should be reconsidered the direction of chemistry education prepared the identity of teacher's college reflected in this actuality.

32. P3-B16

REPRESENTATION OF 'ORIGIN OF UNIVERSE' IN THE NEW HIGH SCHOOL SCIENCE TEXTBOOKS, 'BLENDED SCIENCE' IN KOREA

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It has been emphasized that nature of science, process of science, and true-science than simple transmitting scientific knowledge since movement of secondary and university level science education revolution. Many science educators have suggested that involving history and philosophy of science in science curriculum can be helpful for students' understanding scientific concepts and be effective for development of scientific thinking. Eger (1989) mentioned that there are two fundamental interests of science; technical and cosmological interests. He thought technical interest would be cause of purposive-rational action through instrumental methodology. Cosmological interest, on the other hand, would be cause of hermeneutic-communicative action through reflective methodology. He argued that current science education or most science textbooks emphasize mainly one interest, technical interest, with suppressing the other interest. In Korea, newly designed 'The blended science textbooks' are developed pursuing for cosmological interest and for an integrated understanding about cosmos, life, and human being. In this study, we tried to evaluate the blended science textbooks from the 'interest of science' perspective which Eger proposed. At first, we developed a framework for analyzing the blended science textbooks. There are two types of criteria; instrumental and reflective (hermeneutic) type. Based on this framework, we evaluated seven blended science textbooks. We will introduce the results and implications of this study.

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ANALYSING THE GAP BETWEEN INTENDED AND IMPLEMENTED PHYSICS LABORATORY ACTIVITIES

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This paper focuses on analyses of the match between teachers' objectives expressed in the interviews and laboratory instructions and students' activities in the pendulum experiment at the National University of Laos. Seventeen groups (72 students) doing the pendulum experiment were video recorded. Five physics teachers and nine students from some recorded groups were interviewed. In addition, thirty lab reports by students from previous years and from the recorded students were analysed. The framework for analysing the video recordings, the interviews and the lab reports was a modified version of the Practical Activity Analysis Inventory (PAAI) by Millar (2009). The gap between intended and implemented physics laboratory activities was identified. None of the recorded groups attained completely what the teacher intended students to do (effectiveness at level 1). The analysis showed that the most successful group completed three fourth of the tasks that the students were supposed to do. All the other groups completed at most half of the tasks. Students conducted measurements but they seemed to not understand the important concepts of the experiment task. Nearly all students had difficulties of using equipment to carry out measurement. Only three out of nine students who were interviewed affirmed that they have learnt technique to measure the period of the pendulum and better understand the process to carry out measurement. Teachers expressed an opinion that generally students do not study hard. Many students did not complete writing a lab report of the previous session before coming to the next experiment class. Many lab reports presented a correct mathematical calculation procedure but obtained a value of g far from the literature value of $9.8 m/s^2$. This happened due to collection of inaccurate data from measurements or treatment of data in the wrong way. The findings indicated that here was a big gap between what teachers intended the students to learn and what students actually learnt (effectiveness at level 2).

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