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WELCOME LETTER FROM EASE President

We are very pleased to invite EASE members and other science educators and scientists to the forthcoming EASE 2015 conference. This conference will be held at Beijing Normal University, Beijing, China, on 16–18 October, 2015. Beijing, the capital of China, is the country's political, cultural, and educational center, where tradition and modernity coexist harmoniously. We are sure that you will enjoy the history, vigor, beauty, modernity, and diversity of Beijing.

The theme of the EASE 2015 Conference is "Promoting Science Education Reform Through Research". The conference aims to build an international platform for science education practitioners, researchers and policy-makers throughout the East Asia regions and around the world to share and discuss how to promote science education reform through research.

We sincerely believe that the EASE 2015 Conference will be a place where you can share your research interests, build relationships with your colleagues, and enjoy Beijing. We look forward to meeting you in Beijing in October 2015.

Lei WANG

Chair, Organizing Committee of EASE 2015 conference

For more information, please contact us or visit the conference website.

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May 1, 2015	Abstract submissions due
June 1, 2015	Notification to authors
August 1, 2015	Early bird registration deadline
September 1, 2015	Registration deadline

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Trends and Development in School Science Education in Hong Kong

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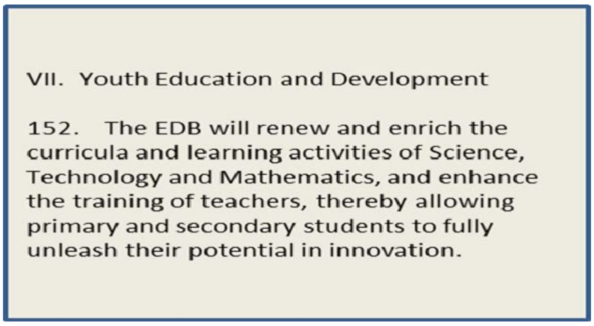
2015 Policy Address

In the 2015 Policy Address (Hong Kong Government, 2015), it was announced that the Education Bureau will "renew and enrich the curricula and learning activities of Science, Technology and Mathematics, and enhance the training of teachers, thereby allowing primary and secondary students to fully unleash their potential in innovation."


VII. Youth Education and Development

152. The EDB will renew and enrich the curricula and learning activities of Science, Technology and Mathematics, and enhance the training of teachers, thereby allowing primary and secondary students to fully unleash their potential in innovation.

Overview of School Science in Hong Kong

Science education is one of the eight Key Learning Areas (KLAs) in the basic school curriculum of Hong Kong, it aims to provide "learning experiences through which students acquire scientific literacy" and "develops the necessary scientific knowledge and understanding, process skills, values, and attitudes, for their personal development, and for contributing towards a scientific and technological world" (Curriculum Development Council [CDC], 2002, p. iii). Science education is compulsory for Primary 1 to Secondary 3 students in Hong Kong.

As a single subject for decades in primary schools, the subject "science" was integrated with other Key Learning areas of personal, social & humanities education and technology education in **General Studies (GS)** in 1996. GS provides learning experiences for students to have a better understanding of themselves and the world around them; arouses interest in and develop students' skills to enquire about science, technology, and society; and cultivates positive attitudes and values for healthy personal and social development (CDC, 2011).

For junior secondary level, Integrated Science for Secondary 1 to 3 was introduced at the end of the 1970s. Since 2000, a revised syllabus, **Science (S1-3),** has been implemented with the aim to help Hong Kong students "develop the necessary scientific and technological knowledge and skills to live and work in the 21st century" (CDC, 1998, p. 2).

For decades, senior secondary science education in Hong Kong was usually highly exam-oriented. Under the new 334 academic structure proposed in 2009, Study of the three different areas of **Biology**, **Chemistry** and **Physics** as well as Science, which consists of two modes, namely **Integrated Science** and **Combined Science**, are introduced to senior secondary students as elective subjects. This design of senior secondary science education aims "to develop in students the scientific literacy essential for participating in a dynamically changing society, and to support other aspects of learning across the school curriculum" (CDC, 2014, p.2).

Future direction for school science education

The changes and development of science education in Hong Kong has witnessed the changes locally and internationally. Along with many other education systems, the focus of science education in Hong Kong moves from instilling basic scientific knowledge to a better awareness of the connections across science, technology and mathematics in modern society, which is critical to innovation capacity for Hong Kong's future development.

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Teach Science-related Interdisciplinary Subjects

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This proposed project involves the development of a new set of foundation science modules for the shared use by the science education faculty of three Hong Kong tertiary institutions, namely the Hong Kong Institute of Education, Chinese University of Hong Kong, and University of Hong Kong. The modules will be delivered in a blended learning mode. The aim of designing these modules is to equip student teachers who lack foundational knowledge in science with the necessary knowledge to enable them to fully benefit from the teacher education programmes of these institutions. These science modules will provide supporting learning materials for the existing science-related teacher-training courses that equip student teachers with the content knowledge they need to teach science-related subjects in primary or secondary schools. These modules are designed for blending with existing courses in a flexible way that combines the advantages of e-learning and face-to-face contact. The e-learning or online-learning components will be delivered through Moodle, a Learning Management System (LMS). This learning environment allows for self-pacing under the guidance of the course tutor. Students can work toward different goals by building on their own background knowledge. This project, the first of its kind, will build the capacity of science education faculties to design and implement creative and innovative curriculum designs and pedagogy to address curriculum and learning issues in teacher education.

The overall objectives of the project are as follows:

1. Develop new foundation science modules that improve student teachers' basic scientific knowledge as a foundation for building further content knowledge and pedagogical content knowledge in teacher training programmes.
2. Build student teachers' capacity for scientific thinking as a basis for developing critical reasoning.
3. Create a learning environment that fosters self-paced learning among student teachers to help them adapt to the change in the quality of learning demanded by learners who are migrating from the secondary to the tertiary level of study, and from the role of learner to that of teacher.
4. Provide role models for student teachers on the use of interactive e-learning strategies blended with classroom teaching to extend the pedagogical repertoire of student teachers who will be teaching science-related subjects.
5. Build the capacity of teacher education faculties to develop an innovative shared curriculum and pedagogy to address common concerns in teacher education.

To realise these objectives, this project will involve four progressive stages of development. The first stage is the design of learning modules that can be integrated into existing teacher education courses to enhance student teachers' understanding of basic science. Such understanding will form the basis for student teachers' further development of science-related content and pedagogical knowledge and skills. The design of the learning process will be based on the 5E Instructional model. As guided by this model, the learning process will involve seven steps although these steps can be modified and integrated to meet the needs of individual courses.

Step 1: Learners' self-analysis of needs based on their understanding of the topics as revealed by diagnostic tests; this step facilitates grouping and topic assignment.

Step 2: Presentation of triggers/scenarios to motivate students to investigate the underlying scientific concepts ***(Engagement).***

Step 3: Inquiry into the topics through learner-centred individual or group activities supplemented with systematic inputs such as virtual lectures and computer simulations and modelling ***(Exploration).***

Step 4: Development of explanations relevant to the inquiry with the support of online and face-to-face tutorials ***(Explanation).***

Step 5: Application of scientific concepts/skills to wider contexts to facilitate deeper learning.

Step 6: Self-assessment with outcomes feeding back to the student and tutor ***(Elaboration).***

Step 7: Developing personalised learning portfolios using the e-portfolio tool available in the LMS to facilitate self-monitoring and the regulation of learning progress ***(Evaluation).***

The second stage is the piloting of these modules in relevant courses. The third stage is the evaluation of the trials. The final stage is the revision of the module design for more effective learning and integration with existing courses based on the evaluation outcomes. For actual implementation, these four stages will be integrated with each other as appropriate.

An Innovative Programme for Learning Physics in the Ocean Park

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A team of educational researchers from the Hong Kong Institute of Education (HKIEd) collaborated with the Ocean Park (OP) in Hong Kong to develop a new physics education programme for implementation in the OP since 2012. OP is a very famous park which won the prestigious Applause Award and was recognized as world's best theme park in year of 2012. This knowledge transfer project aims to design a kind of community-based science learning specifically for senior secondary school physics students. It is built upon three of the OP's newly constructed rides namely "Whirly Bird" (also known as aviator, which moves in a circle over 30 meters in the air), "Bumper Blasters" (also known as bumper cars which bumps and jolts other cars) and "Hair Raiser" (commonly known as the roller coaster which plunges and loops around with player's legs hanging in the air).

Figure 1 Three new rides in the OP (from left to right): whirly bird, bumper blasters and hair raiser

Apart from the exciting rides available in the OP, the HKIEd team made innovative use of digital technologies in this programme for allowing participants to conduct simulation experiments to triangulate with their experiential learning. The HKIEd team also provided on-site training to the OP education officers, equipping them with the appropriate pedagogies for facilitating participants' effective learning through active engagement in the programme activities. There was a comprehensive evaluation of the learning effectiveness of the programme using the Force Concept Inventory as developed by Hestenes et al. (1992) for pre-test and post-test of participants' academic performance, a self-developed questionnaire to collect participants' perceptions and views of the programme as well as interviews of selected students and feedback from teachers (Tho, Chan, & Yeung, 2015; Tho, Yeung, & Chan, 2013). There were a total 201 participants who agreed to get involved in the evaluation process on a voluntary basis. Two educationally significant findings on enhancing the students' physics learning were revealed: traditionally large gender differences in physics performance and interest of learning are mostly eliminated; and a less exciting ride called the aviator (instead of the most exciting roller coaster ride) can induce the largest learning effect (or gain in academic performance) amongst teenagers. From the survey and interviews of selected participants, the new programme was found to be attractive and favourably rated by the participants and the relevant comments or feedback could provide valuable insights for future development of other similar community-based programmes.

After the evaluation period, a total of 2337 students from 60 local secondary schools had participated in this physics programme. The table below shows the descriptive statistics of the participants from July 2013 until June 2015.

	July 2013 - June 2014	July 2014 – June 2015	Total
No. of participating schools	23	37	60
No. of participating students	1162	1175	2337

More recently, teachers also provide several insightful comments about this programme as listed below:

- The teacher thought the programme is flexible and fit the school needs.
- The teacher liked the idea of using rides to learn physics
- The teacher loved the part which the students need to design a track for the roller coaster.
- The teacher thought that the experience the thrills part which allowed the students to experience how the Physics theories applied in the rides matched the school's needs.
- The teacher thinks that the program match the Hong Kong senior secondary physics syllabus and can provide real-life example for student to explore.

Figure 2 Indoor practical work (left) circular motion and (right) roller coaster

In addition, a special arrangement of educational visit to OP had been made during *International Conference of East-Asian Association for Science Education 2013*. The participants had the chance to visit several science education programmes including this new physics education programme.

Figure 3 Educational visit to Ocean Park during EASE 2013

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Plastic Recycling Education Project in Hong Kong

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In Hong Kong, the latest government statistics show that there were around 9,547 tons of municipal solid waste (MSW) produced daily in 2013 (Environmental Protection Department, 2015). Unfortunately, there are only three local landfill sites to handle such a large amount of waste, and they will be fully saturated in the coming ten years. In terms of the composition of MSW, putrescible waste ranks number one (44%), followed by plastic (20%) then paper (19%) (Environmental Protection Department, 2015). Plastic wastes are most concerned not only it ranks second, it is difficult for it to degrade naturally and it can still be "alive" in the landfill sites for hundreds of years. Incineration of plastics may also emit toxic gases and cause harm to humans. To combat these problems of plastic waste, recycling is one of the solutions.

Plastic waste recycling

Plastic waste can be classified into seven types according to the polymer from which it is made, as shown in Table 1. In 1988, the Society of the Plastic Industry established these plastic classification codes (resin identification code, RIC) to facilitate plastic recycling, as mixing different plastic types together will worsen the quality of the reprocessing products.

Table 1. Plastic types and examples

Number	Plastic type	Examples stickers on the bin
1	PET	Soft drink bottle, water bottle, cooking oil bottle
2	HDPE	Detergent bottle, shampoo bottle, juice bottle
3	PVC	Disinfectant liquid bottle, water pipe, shower curtain, label
4	LDPE	Food packaging bag, T-shirt bag, gloves
5	PP	Ice-cream container, cup, folder, bottle cap
6	PS	Live lactobacillus drink bottle, transparent CD case, foam food box
7	Other	Toy car, nylon bag, reusable water bottle, pump dispenser

(EPD, 2011)

Currently, all types of plastic waste are dropped into a single compartment plastic recycling bin. This causes cross-contamination of the recyclables collected, and further affects the recycling quality. It also makes the re-sorting process more time-consuming and increases the labour costs of the recycling industry. A series of research and development studies has been proposed by the Research Centre in Education for Environmental Sustainability (CEES) of the Hong Kong Institute of Education (the "Institute"), including education in plastic waste recycling and the invention of a new plastic waste collection bin with the aim of facilitating plastic recycling. The following are examples of the work of the CEES.

Education in plastic waste recycling

Research had been carried out to examine the impacts of the inquiry learning strategies employed in a 'Plastic Education Project' on primary pupils' knowledge, beliefs and intended behaviour (So, Cheng, Chow, & Zhan, 2014). Three sets of inquiry learning strategies, a plastic recycling card game (Figure 1), hands-on activities (Figure 2) and experimental learning (Figure 3) were employed. Questionnaires and a test on plastic types were used for data collection. The results revealed that the inquiry learning strategies significantly improved pupils' knowledge of the types of plastic waste and their beliefs. However, the strategies seemed not to change pupils' intended behaviour regarding plastic waste classification and management. This study inspired further thoughts on developing another education tool to facilitate the practice of plastic waste classification.

Figure 1. Plastic recycling card game.

Figure 2. Hands-on activities

Figure 3. Experimental learning

Development and the use of 8-bin

The current single compartment plastic recycling bin for plastic waste does not seem to be helpful in terms of facilitating the practice of plastic waste classification. Making reference to the seven types of plastic, a multi-compartment plastic recycling bin was considered. To design a new plastic recycling bin, the bin and compartment size were studied. After reviewing the plastic waste data from Taiwan, Japan and Hong Kong, the volume percentage for the compartment size of the respective 8 compartments of the bin with 8 compartments (8-bin) was concluded as follows:

Theoretical percentage volume of the 8 compartments of the newly design bin

Compartments	1	2	3	4	5	6	7	8
Plastic types	PET–1	HDPE–2	PVC–3	LDPE–4	PP–5	PS–6	Other–7 / Unidentified	Blended Polymer
Percentage by volume	40%	12%	4%	4%	16%	4%	10%	10%

The newly designed 8-bins have been put into use in the Institute's student halls. Their use has been supplemented with a research design to measure the factors contributing to a better quality of plastic waste recycling by measuring cleanliness, separation, sorting and compression of waste. The plastic waste is collected weekly, and ten plastics from each compartment are randomly picked for analysis. The results of the analysis of the 8-bin with and without a poster showing plastic waste sorting information and proper recycling steps installed in different student halls are compared.

Figure 4. Appearance of the 8-bin.

Figure 5. Plastic waste analysis.

The 8-bin has also been introduced to local primary schools. Meanwhile, these schools also received different interventions such as a poster and an 8-hour plastic classification course. In primary schools with 8-bin and poster intervention, pupils' plastic sorting knowledge significantly increased (n=101, p=0.058). Pupils' plastic sorting knowledge also significantly increased with course intervention (n=97, p=0.008). The results showed that, with proper strategies and education, plastic recycling behavior and knowledge can be improved.

Train-the-trainers for a sustainable future

To sustain the recycling knowledge, belief and behaviors, teaching and learning are critical. Train-the-trainer programmes are held to train the Institute's student teachers to be green ambassadors for transferring the message of plastic waste recycling to primary school pupils. The research design embedded in this train-the-trainer programme is to examine the effect of simulation-based learning by identifying student teachers' features of pedagogy content knowledge and their learning experience, which are helpful in providing insights for enrichment of the programme in the future.

Figure 6. Students buying at the "Market" counter during a simulation-based class.

Figure 7. Students presenting during an inquiry-based class.

Conclusion

It is never easy to initiate a new behavior in plastic recycling. With a suitable recycling tool, promotion and education, changes in knowledge, attitudes and behaviors towards plastic recycling would be largely enhanced. It is hoped that the above series of studies can provide some insights to educators and teachers to employ appropriate strategies to educate our next generation in plastic recycling and waste management, which will eventually facilitate environmental sustainability.

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Remote-controlled Laboratory for Science Education

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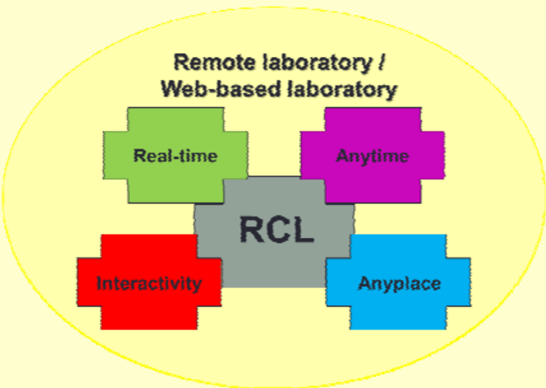
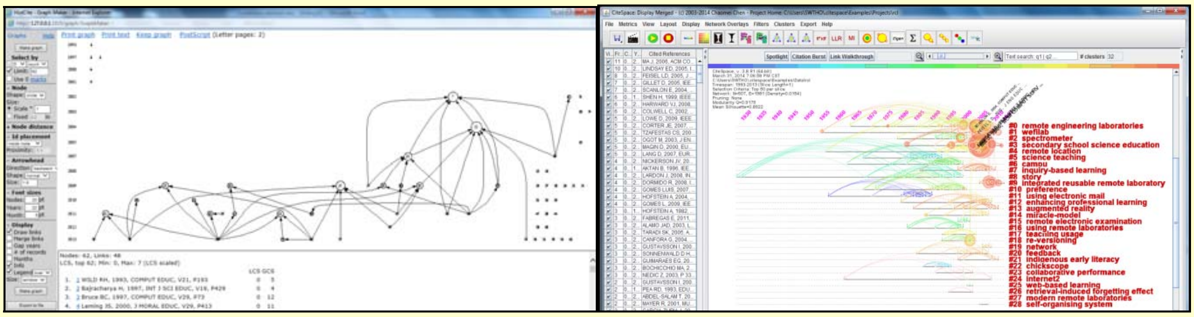
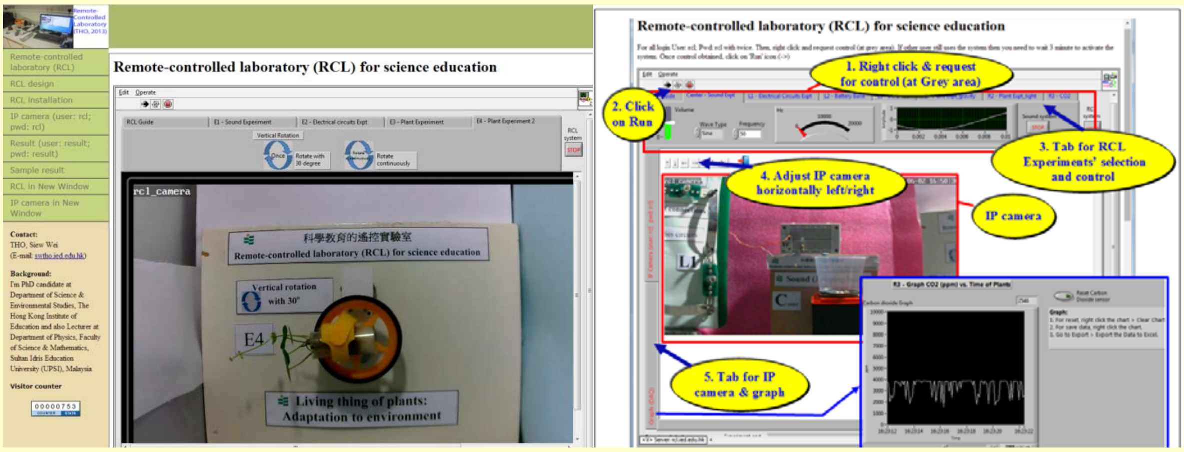
This paper reports the research on the successful development of a novel remote-controlled laboratory (RCL) system through some innovative ideas and methods for practicing technology-enhanced learning of science education particularly secondary school. The Internet-based RCL system enables learners to control and observe the server-side laboratory equipment as well as to perform real-time scientific investigation activities at distant places (Tho & Yeung, 2014, 2015). The following figure shows some important characteristics of RCL system. Thus, this RCL system may overcome some conventional laboratory work problems related to limited class time, places, weather, health, safety, and accessibility (Cooper & Ferreira, 2009; Grober, Vetter, Eckert, & Jodl, 2008; Kong, Yeung, & Wu, 2009; Tho & Yeung, 2014, 2015).



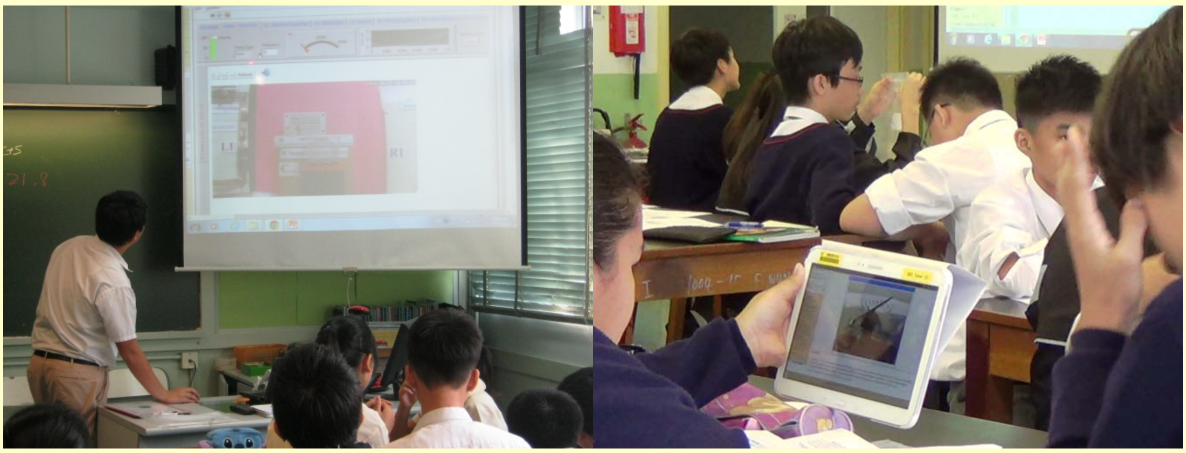
In this study, a series of review processes involving a systematic review of laboratory work and RCL in science education with innovative software (HistCite [http://interest.science.thomsonreuters.com/forms/HistCite/] and CiteSpace [http://cluster.ischool.drexel.edu/~cchen/citespace/download.html]) for visualizing their structure were also conducted (Tho, Yeung, Wei, Chan, & So, 2014). It is believed that the results of this systematic review can provide more insights into laboratory work to inform classroom practices with the existing evidence base and identify areas for further research. Hence, the relationship of the cited works was observed in the historiographs of laboratory work and RCL research studies through HistCite analysis. Then, more information about RCL was obtained with CiteSpace analysis, which identified a manageable number of studies for further consideration. Figures below show the HistCite graphmaker (Left) and the Citespace cluster (Right) displays of RCL studies.



Then, three iterative cycle testing and refinements were performed. The evaluation of these three iterative cycles was performed using a mixed research method that included achievement tests (for the secondary students only), questionnaire survey, open-ended questions and interviews specifically developed to collect data on student understanding, perception, and implementation of the use of the RCL system. First, a set of newly developed RCL system involving four remote experiments was initially tested by undergraduate students who studied science education and web technology and were enrolled in teacher training courses (Tho & Yeung, 2014). The following figures show part of the remote experiments before (left) and after (right) refinement.



Then, a refined RCL system involving eight remote experiments was then evaluated by two Hong Kong secondary schools as second and third iterative cycles. Figures below show secondary student presentation (left) and student performing the solar remote experiment (right).



Based on the findings, the results of achievement test revealed that the secondary students had better understanding of the related science topics. In addition, the survey findings showed that the participants agreed with the appropriateness of various educational merits of the RCL system and the ways of conducting those innovative experiments. However, negative comments and suggestions for improvement were identified. Based upon these, the RCL system has been refined and this newly developed system can be used as laboratory activities and demonstration kit for science learning and teaching process.

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The preferred methods of environmental education in Hong Kong

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Abstract

A public environmental consciousness survey has been undertaken in Hong Kong in 2013. Results from this survey suggested that although experiential learning approach is a preferred method for environmental education, the busy life style of general Hong Kong people would be the main barrier of participation. Traditional forms of media such as television, newspapers and magazines are still commonly used by Hong Kong residents to access information about environmental issues. Nonetheless, the young generations are more adapted to the digital world, whose role in disseminating pro-environmental information has been increasing in recent years.

1. Introduction

Environmental issues have become pervasive in our daily lives and there has been an increase in public concern on the degradation of the environment in recent decades. The Hong Kong SAR government has been a major player in the promotion of public environmental awareness in the local arena and has funded the Department of Science and Environmental Studies of the Hong Kong Institute of Education to conduct a survey on the status quo of environmental education in Hong Kong. This survey aimed to evaluate the current level of environmental consciousness among members of the general public and to identify suitable programmes for environmental education in the future. In this article, I would highlight our findings concerning methods of environmental education and our recommendations.

2. Methods

The survey was conducted in the form of structured face-to-face street interviews from 12 December 2012 to 20 January 2013. Local residents in Hong Kong aged 15 and above were chosen as the target population for this study. A proportional stratified sampling approach on the basis of age groups was adopted as the sampling strategy. The survey was conducted in six selected locations from each geographical constituency of the Legislative Council election of 2012 (a total of 30 sampling sites). The questionnaire was divided into five parts: (i) Environmental Knowledge, (ii) Environmental Attitude, (iii) Pro-environmental Behaviour, (iv) Methods of Environmental Education, and (v) Demographic Characteristics. The interviewers approached 5,904 qualified residents and 1,033 responded to the questionnaire, yielding a response rate of 17.4%. In this article, I would highlight some of the findings with part (iv), methods of environmental education.

3. Summary of selected results

- Concerning their preferences in methods of environmental education, the respondents were most interested in outdoor tours (43.2%), followed by exhibitions (33.1%), visits (31.9%) and online resources (26.7%), see Figure.
- Most respondents had participated in environmental protection-related activities that were organized by community organisations (47%), schools (32.5%) or the government (20.3%).
- More than half of the respondents had participated in environmental activities to enhance their knowledge (60.6%), to do

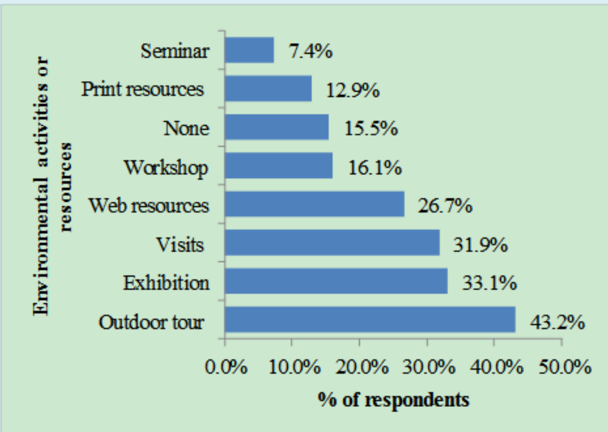

Figure: Types of environmental activities or resources of interest to the public something for the environment (50.3%) or to strengthen their personal networks (21.3%).

- The majority of the respondents (72.3%) said that their main reason for not participating more was that their schedule was not suitable. Some 25.1% of the respondents attributed their infrequent level of participation to the lack of promotion for environmental activities.
- The majority of the respondents said that they obtained environmental information from television (75.9%) and newspapers (72.8%). The younger generation also tended to access information related to the environment through digital-age media (Internet/forum/Facebook).

4. Recommendations

The survey results revealed that traditional forms of media such as television, newspapers and magazines are still commonly used by Hong Kong residents to access information about environmental issues. A majority of Hong Kong citizens are passive learners in acquiring environmental knowledge through these channels. Given the wide user base for traditional forms of media such as television and newspapers, these media represent the best channels for disseminating pro-environmental messages to the public in general, and to the elderly in particular.

The digital world now plays an important role in disseminating information, and it provides an effective platform for access to information by the public. This study shows that use of the Internet in exchanging information on environmental issues has become very popular, in particular with the younger generation. Consequently the Internet will have a significant role in the promotion of environment protection. Web-based environmental education programmes such as online games and mobile apps can be developed to disseminate pro-environmental messages to a larger audience.

Regarding the preferred methods of environmental education, the respondents in this study were most interested in outdoor tours, exhibitions and visits. Given their wealth of local knowledge, community organisations should provide more outreach activities such as visits to waste recycling facilities. The participants in such visits will have the opportunity to learn about local environmental issues through the viewpoints of different stakeholders. Moreover, such visits can stimulate the participants' thinking over environmental issues of relevance to Hong Kong, and may encourage them to learn from multiple perspectives. Such development of thinking in multiple perspectives is especially needed, as Hong Kong is a region where the causes, consequences, and solutions of many local environmental issues are complex and multifaceted.

How to use pictorial representations to promote conceptual understanding when reading scientific magazines

Dr Irene Chung-Man LAM

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Introduction

Reading is one of the 4 key tasks proposed by the Curriculum Development Council (2001) and is widely used across the curriculum. Various teaching and learning materials related to Chemistry curriculum, such as "Learning and teaching activities for sixth form chemistry curriculum, 2005" and "Promoting the quality of chemistry learning with active reading and writing tasks, 2008", were developed by the Science Education Section of the Education Bureau. Reading is also one of the strategies presented in the New Senior Secondary (NSS) Chemistry curriculum and assessment guide (2007), which states, "Reading to learn promotes independent learning. In particular, it enables students to understand various aspects of the past, present and possible future development of chemistry. Students should be given opportunities to read science articles of appropriate breadth and depth independently. This will develop their ability to read, interpret, analyse and communicate new scientific concepts and ideas." There is no doubt that reading scientific magazines is an important aspect of the study of science and lifelong learning. However, most students perceive reading this type of text as leisure and learn little from the text, and most science teachers adopt traditional pedagogy such as expository teaching or deductive experiments. Science teachers mainly use textbooks as the teaching and learning material because of their accessibility and because no specific strategies are required with their use. Many studies (King, 2007) emphasize the importance of reading strategies in understanding text. The current article will discuss reading strategies based on the integration of theories of cognitive process of reading, self-regulated learning and dual coding theories to address pictures in scientific magazines.

The uses of pictorial representation in building mental models

According to Carney and Levin (2002), students can better comprehend text if appropriate pictures are illustrated in line with the descriptions or explanations in the text because these pictures can help students build mental models that extend beyond definitions and rote learning to make inferences about the text. This is further evidenced by Mayer (2005), who found that presenting materials in multiple representations of information, such as text, pictures and video, can facilitate mental model acquisition. Because appropriate pictures can serve as external depictive representations, they lead to both internal depictive and internal descriptive mental representations. There are five types of pictorial representations, namely, decorational, representational, organizational and interpretational representations, which have conventional functions; and transformational (mnemonic) representation, which has an unconventional function. Decorational pictures have no or little connection to the text, such as a portrait of scientist Faraday. Representational pictures portray a portion or all of the text and are most commonly used in narrative text. In scientific magazines, representational pictures are often used to illustrate experimental set-ups or abstract concepts such as the atom. Organizational pictures are used to provide a structural framework of the text such as a concept map, flowchart or picture involving different positive and negative ions. Interpretational pictures serve the function of clarifying complex concepts, such as the formation of ionic compounds consists of a series of steps. Transformational pictures use memory-enhancing components such as different colours so readers can recall the text easily. An example is the use of different colours to show the types of ions formed using the periodic table as a framework. Research conducted by Carney and Levin (2002) has shown that decorational pictures do not help readers understand the text and that the positive effect size increases from representation pictures to transformation pictures. This is the reason why interpretational and transformational pictures are widely employed in scientific magazines.

According to cognitive load theory by Paas, Renkl and Sweller (2003), when the cognitive load is over the capacity of a student's working memory, the student's learning is hindered. There are three types of cognitive load present during reading, as follows: intrinsic cognitive load arises from the complexity of reading text; extraneous cognitive load arises from the incomplete design of the text, such as lack of appropriate pictures to explain abstract scientific concepts; and germane cognitive load generates the automation and construction of a schema that leads to deeper understanding. Therefore, an effective reading strategy could focus on how to minimize extraneous cognitive load and maximize germane cognitive load simultaneously. Does the interpretation of a picture increase cognitive load and hinder learning? Paivio's dual coding theory (1986) states: "Human cognition is unique in that it has become specialized for dealing simultaneously with language and with nonverbal objects and events. Moreover, the language system is peculiar in that it deals directly with linguistic input and output (in the form of speech or writing) while at the same time serving a symbolic function with respect to nonverbal objects, events, and behaviors. Any representational theory must accommodate this dual functionality." This theory suggests that readers process the text and image in two cognitive subsystems simultaneously and that, accordingly, the interpretation of a picture will not increase readers' cognitive load. Based on the theories above, appropriate pictorial representations could help students understand scientific magazines to a certain extent without burdening their cognitive load. However, Weidenmann (1989) argued that readers may examine the appropriate pictures superficially, as they overlook the pictures or perceive them as "easy" materials. Teachers should provide scaffolded instruction to ensure that students fully utilize the pictures when they read scientific magazines.

The uses of self-regulated learning in reading

Self-regulated learning theory consists of the following three components: metacognitive awareness, strategies used and motivational control (Bruning & Bruning, 2004). Many studies evidenced that students who engage in effective planning generally exhibit better performance (e.g., Boekaerts, Pintrich, Zeider, & ebrary, 2000). Pressley & Gaskins (2006) describes the metacognitive processes in different reading stages, before reading, during reading and after reading, and the strategy instructions that foster these processes. Souvignier & Mokhlesgerami (2006) reported that skills of cognitive and motivational aspects of self-regulation can maximize the effect of the teaching of reading strategies. Research on metacognitive processes and reading comprehension, such as Concept Oriented Reading Instruction (CORI), examines skills in using strategies to identify important details from text and integrate information using multiple texts. CORI has a dual focus on comprehension strategies and students' motivation to read. Wharton-McDonald & Swiger (2009) reported solid grounding in cognitive strategies instruction, including modelling, scaffolding, guided practice and the conditional knowledge of when, where and how to use the strategies. In light of recent research, instruction on metacognitive reading strategies was scaffolded, and a model of gradual release of responsibility contributed to students' ability to self-regulate while reading (Nash-Ditzel, 2010). Baker & Beall (2009) summarized increased motivation, increased use of reading strategies, and gains in reading comprehension. One of the strategies, K-W-L chart, consists of the following three columns: "What I Know", "What I Want to know" and "What I Learned". This strategy was created by Ogle (1986) and is commonly used to enhance students' comprehension skills and higher order thinking. Teachers ask questions to clarify what students know, and this structural process is the activation of prior knowledge that has been previously discussed. Then, students consider what they want to know before reading, and this process helps them to set goals. After reading, students discuss their reading outcomes and then revisit "Know" to monitor whether appropriate prior knowledge has been used and revisit "Want" to evaluate their goals. However, most students do not set specific goals that prompt deep understanding and, hence, do not activate appropriate schemas when reading scientific magazines. Additionally, science teachers seldom teach reading strategies explicitly. Many studies showed that reading strategies are crucial in enhancing students' comprehension and higher order thinking (Rosenshine & Meister, 1994). Empirical research has shown that the following 5 reading strategies contribute most to learning: determining importance (Pressley & Wharton-McDonald, 1997), summarizing information (Hart & Speece, 1998), drawing inferences (Woloshyn, Paivio, & Pressley, 1994), generating questions (King, Staffieri, & Adelgais, 1998) and monitoring comprehension (Afflerbach, 2002). In the chemistry context, Wilson & Chalmers-Neubauer (1988) classified 4 levels of reading complexities, literal, inferential, evaluative and creative, and stated that different types of questions could be asked to help students achieve each level.

How to use pictorial representation effectively

Based on the theories stated above, a reading strategy using self-regulated learning as a framework is developed for the reading of scientific magazines. There are three stages to this strategy, as follows: the pre-reading stage, reading stage and post-reading stage. The functions of the pre-reading stage are the set-up of reading goals, activation of relevant schemas and generation of questions in accordance to different pictorial representations. The communication level and genre of the article is also deployed so students can select strategies that are in line with the text structure. It is assumed that students will activate relevant schemas before reading the text. The conclusion is that conceptual, abstract questions will be produced when students study interpretational and transformational pictures. One final step, i.e., making predictions from the pictures beyond the K-W chart, is included in this stage to stimulate interest and arouse curiosity. This will cause students to become more goal-directed during reading, as they must verify whether their predictions are correct. This stage not only aims to remind students of the importance of different functions of pictures but also helps them to construct a mental model, which is incomplete but essential for learning.

Reading stage: The pre-reading stage prepares students to be active readers while processing text. Students must find and check the answers they have generated during reading. If there is contradiction between the answers and prediction, they must alter their strategies or goals to find local and global coherence of the text. Strategies include rereading, taking notes, drawing, making inferences, elaborating and summarizing. Students must also revisit the picture and proceed with self-questioning. "Is the mental model built during reading consistent with the mental model established by the picture?" If there is any gap between the two mental models, the student will adopt the strategies stated and revise and integrate the models to acquire conceptual understanding. In summary, students must alternate between the text and the pictures to regulate the reading process. A schematic diagram of the cognitive process is shown in Fig. 1.

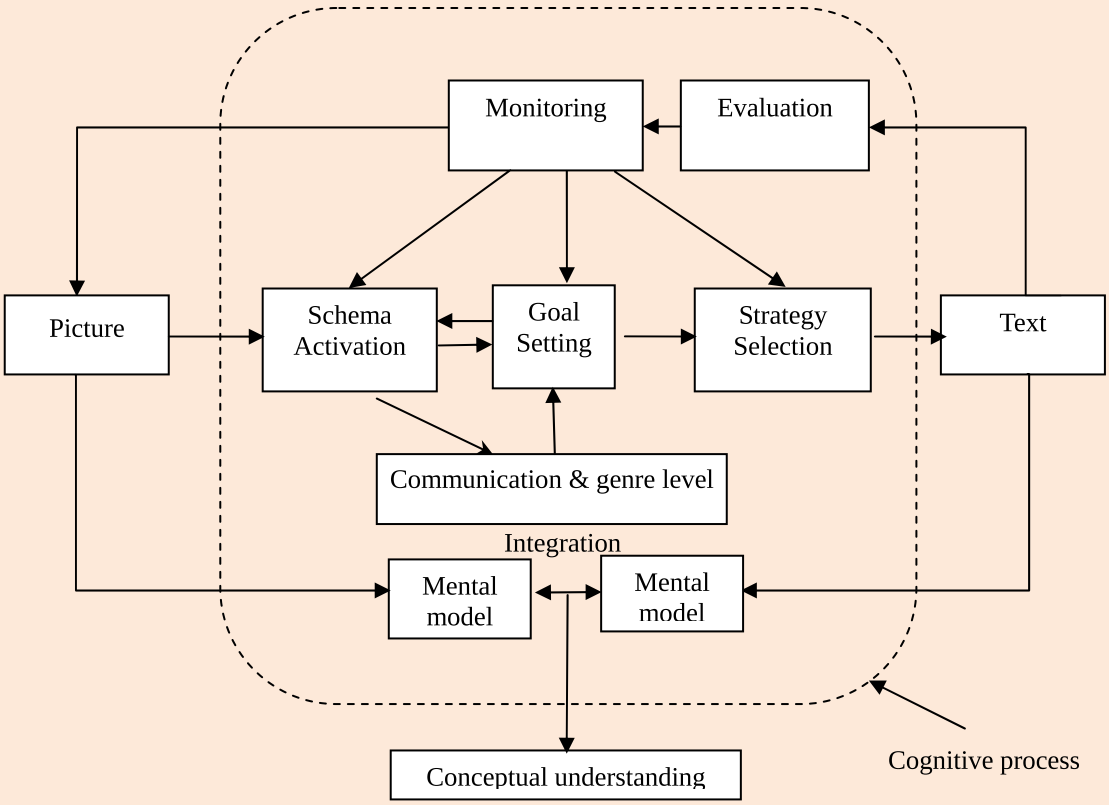

Fig. 1: The schematic diagram of the cognitive process using pictorial representations as goal setting

After students have read the information, the L-Chart can be used to evaluate what they have learned. Additionally, teachers should provide opportunities for students to discuss the process and outcomes of reading with their peers. Post-reading activities aim to facilitate students' integration of scientific concepts in the text with their prior knowledge, retention of concepts, i.e., from working memory to long-term memory, and opportunities for students to praise the text and apply the concepts in daily life.

Implications and Conclusions

The effectiveness of using pictorial representations while reading scientific magazines has not been proven, but it seems that all types of pictorial representations (representation, organization, interpretation and transformational) other than decorational could assist students in setting specific goals and activating schemas. However, if the pictures are very compact and accompanied by many abstract concepts or vocabularies, a question arises concerning whether students' motivation will be lowered and undesirable extraneous cognitive load will be increased. Teachers should select the magazines very carefully, taking into account the prior knowledge of students, the types of pictorial representation and the complexity of the concepts illustrated in the picture. Moreover, teachers must teach reading strategies explicitly and demonstrate these strategies so that students know how to construct meaning from the pictorial representations before, during and after reading scientific magazines. When teachers teach strategies with the purpose of ultimately fostering students' independent and automatic use of these strategies, students can engage in active learning and interact with scientific texts.

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3. 2015 The Conference of the International History, Philosophy, and Science Teaching Group (IHPST), July 22-25, 2015. CEFET, Rio de Janeiro, Brazil
4. 2015 the 11th Conference of the European Science Education Research Association (ESERA), August 31 - September 4, 2015, Helsinki, Finland
5. 2015 California Science Education Conference, October 2-4, 2015, Sacramento, CA
6. 2015 International Conference of East-Asian Association for Science Education (EASE), October 16-18, 2015. Beijing Normal University, Beijing, China, http://ease2015.csp.escience.cn/dct/page/1

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