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AN EARTH SCIENCE COURSE AT KAMNOETVIDYA SCIENCE ACADEMY, A THAI SCIENCE-ORIENTED SENIOR HIGH SCHOOL

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Abstract— A new conceptual earth science course was conducted at a science high school in Thailand. The course contents composed of 32 topics, 50 minutes on each topic, spanning a period of two months. The course is equivalent to 0.5 credit for grade 12th students, as a compulsory subject. The course was conducted mainly in English via lectures given by a Japanese visiting teacher, while resources and the examination were fully supported by a Thai teacher. An adviser from Silpakorn University gave supports and advices on the teaching process. The contents consisted mainly of geology and geophysics. The course also covered a few contemporary controversial issues such as earthquake prediction, dinosaur extinction, and climate changes. Complimentary exercises and experiments were conducted at the same time, concurrently with the PPT presentation of each lecture. Questionnaires were used to assess the course outcomes. Feedback from students clearly indicated that the course was successful.

Keywords— Thailand, high school, earth science, geology, geophysics

Thematic line— "Education in senior high school level"

1 Background of the school

Information on Kamnoetvidya Science Academy (KVIS) can be found at http://www.kvis.ac.th/About_EN.aspx) under the section 'Discover KVIS'. An excerpt of the content is shown below.

"KVIS is a full boarding school providing education with special emphases on mathematics, science, and technology to students of three-year levels comprises Year 10, Year 11, and Year 12 with full scholarship each. With a strong intention to provide customized training to the need of individual student, KVIS thus set out for a small class size. KVIS therefore caters for only four classes for each year level having only 18 students in each class. The total number of students on campus at one time would therefore be 216 students. To effectively "growing wisdom" in gifted young minds, KVIS carefully selected high-performing teachers and staff members while providing salaries and fringe benefits at levels well above country averages.

The school uses English as the main medium of instruction. Apart from laboratory exercises that go hand in hand with lecture components, each student need to complete a research project prior to graduation. Students are trained to make good uses of extensive databases available online to formulate their research projects. Each student has to do a presentation on research proposal, writing a mini-thesis when the research is completed, and to finally present the final results to other students, staff members and invited guests of the school. These activities place heavy demands on staff members and facilities. It is the duty of the school to provide them with good and sufficient scientific equipment and supporting supplies to meet their needs."

To realize those goals, the school currently employs 43 teachers, including foreign visiting teachers and 10 senior advisers who are mainly from co-operating universities. For the academic year of 2017, the M6 (year 12th) students took the earth science course in the first semester. We developed a completely new curriculum and contents of the earth sciences class in co-operation of a foreign visiting teacher and a senior adviser.

2 The KVIS earth science team and Curriculum

In our school the subject matter on earth is called 'earth science'. Also, this year is the first time to establish the subject nature of earth science as a compulsory subject. The KVIS earth science team consists of two teachers and one adviser.

At first, the constructing contents and main lectures were carried out by a Japanese visiting teacher (Yoshio Okamoto) who has a long career in teaching earth science in Japan. Yoshio Okamoto is also now teaching at Osaka Kyoiku University as a temporary lecturer. The second person is Janjira Maneeasan who is a chemistry teacher at KVIS. Janjira Maneeasan graduated with a PhD in biochemistry and began her work at KVIS in April 2017. She managed earth science class for curriculum, daily preparation for lecture resources, discussing the lecture contents and did the VDO recording of the classes. She also checked the daily attendance of students, and assisted in marking the final exams. The third person is Thanit Pewnim who was an instructor at Silpakorn University. Thanit Pewnim is currently the chemistry senior adviser at KVIS who is a specialist on SEM and X-Ray microanalysis. He supports and give advices on the curriculum, encourages the team, and motivates the class to progress in harmony. The team developed a unique ERS (earth science) curriculum, teaching resources, a final exam, assessing students' performances, and grants credits to students.

The ERS course was delivered to four classes of 12th grade students. Each class consists of 18 students. These classes were confined to the period of 31 July to 29 September 2017 to fit the Japanese visiting teacher's schedule.

The course is divided into two categories, the basic course and the advanced course. The basic course covers basic knowledge and concepts of earth science, while the advanced course extends to the study of scientific methods, the special topics, and the applications of earth science.

3 The ERS course contents

Table of ERS course contents is as the followings.

Table 1. The ERS course contents (Purple: our original unique tools, References)

<Basic course>

	Title	Aim	Contents	Tools/materials	Exercises
1	Rock Minerals I	Definition of SiO_4 families.	quartz, feldspar, mica, etc.	Mineral samples and photos	Observation of samples
2	Rock Minerals II	Identification of SiO_4 families.	Metal ions, solid-solution	Minerals Rock samples	Mineral quiz
3	Igneous Rocks I	Definition of igneous rocks	Table felsic acidic, volcanic, plutonic	Polished igneous rock samples,	Igneous rock quiz
4	Igneous Rocks II	Occurrence or igneous rocks	Dikes, sheet, batholis, xenotith	Igneous rock samples, photos	quiz
5	Volcanoes and eruptions I	Classification relation with igneous rocks	volcano classification table	National geographic videos, and protractor	**Mt.Fuji summit angle measurement**
6	Volcanoes and eruptions II	Eruption types and volcano disasters	Hawaiian, Stronbolian, Vulcanian, Pliniyan	Volcanic ash samples (**Kanto roam, A/T ash**)	Microscope observation of volcanic ashes
7	Earthquake I	How to read seismograms	Hypo-center, magnitude (Richter scale)	Seismograms, map, magnitude nomogram	**Original seismograms exercise** **(Okamoto et.,al. 2013)**
8	Earthquake II	Earthquake and focal mechanism, Seismographs	How to study the mechanism of earthquake	P-initial time and phase map of 1995 Kobe earthquake	**P-arrival map exercise, Seimographs** **(Okamoto,2016 Okamoto & Ito,2014)**
9	Earthquake and fault	Relation with fault	Fault mechanism and earthquake	Fault experiment	**Flour fault experiment**
10	Special lecture to all KVIS members at the auditorium	Lessons from 2011Tohoku, 1995Kobe	Disasters and human beings, Japanese cases	PPT lecture	**Own-made tsunami simulations**
			<1st ERS report>		
11	Continental drift	Theory: birth and defeat	Evidences and drawbacks	Photos and maps	Continental drift map puzzle
12	Sedimentary rocks	Classification	Particle sizes, compositions	Photos and samples	sedimentary rock quiz
13	Sedimentary structures	Characteristics	Turbidite, laminae, ripple marks, convolution, etc.	Photos and samples	**Exercise on sedimentary structures**
14	Geological structures	Characteristics	Unconformity, intrusion, faults	Photos and maps	Observation of photos
15	Geological principles	How to read geological profiles	Law of super- position, cross-cutting relationship	Photos and maps	Geological map quiz
16	Geo-history I	Fossils and Paleozoic era	index fossils, facies fossils, Paleozoic fauna and flora	Photos and **Fusulina trilobite samples**	Observation of fossil samples
17	Geo-history II	Fossils II, absolute ages and Mesozoic era	Radiometric dating, Mesozoic and Cenozoic fauna and flora	Ammonite samples, Exponential graphs	Observation of fossil samples, Graph sheet
18	Geo-history III	Cenozoic era and ice ages	Human fossils, ice age remnants, Mirancovic cycle	**South Africa trip photos and video**	Watching videos and photos

<Advanced course>

	Title	Aim	contents	tools/materials	exercise
19	Earthquake prediction I	Why so difficult? G-R law	G-R laws example, simulations of earthquakes	Semi-log and log-log graph papers, PC simulations	**"Go-game model", "Sand-pile model" (Okamoto, 2006)**
20	Earthquake prediction II	Precursors? Characteristic earthquakes?	Earthquake prediction and time-predictable model	**Psychological bias, Chikura map and graph sheet,**	**Random test, Time-predictable model**
21	Complex systems I	What is ?	Power laws and Zipf's law	Fortune global 500 table	**Zipf's law exercise (Okamoto, 2016)**
			<2nd ERS report>		
22	Complex systems II	Fractals, Chaos, SOC	Cell automaton	Grid sheet, rule table	**1-dimensional cell exercise**
23	Earth's interior I	Crust and Mantle	Moho discontinuity, seismic ray theory	**1995 Kobe earthquake. Travel-time data**	**Vp,Vs crust thickness**
24	Earth's interior II	Mantle and Core	P,S shadow zones	Jeffray's Bullen travel-time curve, **seismo-grams**	Fit travel-time to seismo-grams
25	Pre-Plate tectonics	Ocean floor spreading, geo-magnetic survey	Magnetic polar wandering, and ocean floor geomagnetic anomaly	"Red October" video, Basalts, Iron needles, Dishes	Basalt NRM, **Ocean fl our geo-magne model (Okamoto & Imura, 2014)**
26	Plate tectonics	Basics of plate tectonics	Subduction zone, mid ocean ridge and transform faults	Plate map, **original transform fault paper model,**	**Paper model of transform fault, Zambia trip video 3D seismic maps (Okamoto,2011)**
27	Burgess biota	Missing lives, punctuated evolution	My Burgess shale trip, and the meanings of Gould's "Wonderful life"	Burgess fauna resources, **Canadian Rockys video**	watching videos "Its a wonderful life", **my trip video**
28	Mass extinction	P/T and K/T mass extinction	K/T asteroid impact theory	Alvarez paper (Science, 1980), PPT	**Dinosaurs fossil site video (Okamoto, 2006)**
29	Early earth I	Hadean era and Giant Impact Theory	Origin of Moon, oceanic crust, life, BIF, Moon and life evolution	**South African rocks, Barberton fieldtrip video**	**Old life sandstone, BIF and gold ore. Other Photos and samples (Okamoto,2017)**
30	Early earth II	Archean era and the Snow Ball Earth	Snow ball Earth, what, cause and evidences	Canada-Japan made video, **my NY trip video**	Watching "snow ball earth video"
31	Climate changes I	Basics of Paleo-Climate	Climate proxy indexes	Photos and Vostok core data	**Coloring graphs**
32	Climate changes II	Global warming controversy	Skepticism and IPCC scientific basis	documents for controversy	**Checking the both side documents (Okamoto, 2006)**

<final ERS report>

<1st Report>
About the Tohoku2011 and the 1995Kobe earthquakes
(7% assignment)

<2nd Report>
About the Zip's law or power laws
(7% assignment)

<Final Report>
About the Title: Our existence—chance (randomness, accidentally) or necessity (lawful consistency)?
(Any format is welcome, short story, SF, animation or something else)
(7% assignment)

<Final Exam>

Multiple choice questions: 40%
Witten exam questions: 60%
Time: 90min

<Short notes>
The contents of our course are limited in geology and geophysics, while meteorology and astronomy parts will be covered by other courses at KVIS.

In the basic course, we treated the basic knowledges and thought process which are popular in earth science common text books.

The advanced course are one of our new challenges on how to teach earth science for science-oriented high school students. Therefore, we adapted the college-level contents that are related to developing new science fields. For example, the complex system concerning with the disaster forecasts. For this purpose, we used completely new educational kits of our own made. It is clear that the students experienced the contemporary cutting edges of earth science, such as early earth and climate changes with new discoveries and hypotheses. Apparently, these contents are generally not covered in earth science classrooms at the high school level in the country.

The assessment of this ERS class was based on 10% attendance, 20% assignment (Three reports above) and final exam (70%). It was necessary for some students to take an additional exam or extra works when their overall scores were lower than 60%.

4 Teaching methods

We used the Microsoft PowerPoint for lecture presentation and the printouts for certain exercises. Our classroom had a large white board in front of the room and we could use color pens to further explain and discuss the subject matters, as well as doing exercises directly on the PPT images projected on the white board. This kind of setup did facilitate students to do exercises effectively. Also, a counterpart Thai teacher, sometimes facilitated the teaching if the students got confused or did not understand English. The teaching fundamentary carried out with a PPT lecture, including question-based process with some practical materials or exercises. If needed, writings on a white board could also be used.

We adopted the followings when conducting the ESR course.

1) Used real samples (minerals, rocks, seismograms and film-based videos etc.) instead of virtual information as much as we can.
2) Began with earthquake and volcanic-based content, including their disaster forecasting methods.
3) Used short experiments and practices rather than lecture only.
4) Included certain topics beyond the high-school level, such as complex systems related to earthquake prediction.
5) Simulation-based techniques or PC models were employed in conjunction with the (4) above.
6) Included cutting edge controversies or hypotheses in earth science which had never been cover in a standard high school level.

5 Examples of teaching resources

The next pages show photo examples of the practices discussed above.

Some exercises used our original tools and data. Using these tools, they could learn not only scientific knowledges, but also the methods on how science reveals the complexity of nature. Also, they recognize the vast scale of the earth as well as its history.

<Classroom teaching>

Figure.1 A classroom of 17 students

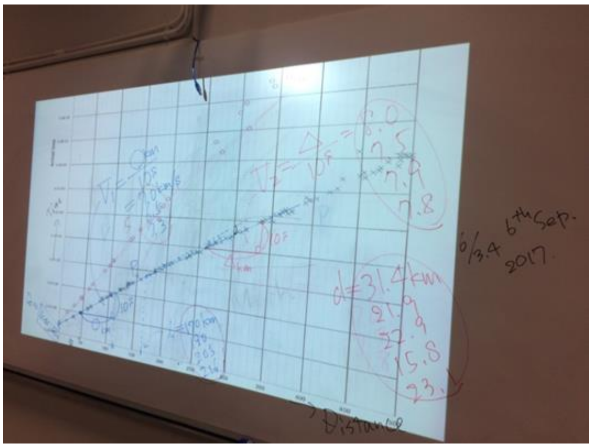


Figure.2 White board writing on a PPT image

<Using real materials>

Figure.3 Microscope observations of volcanic ashes

Figure.4 Watching a sample box of sedimentary rocks

<Graph Exercises>

Figure.5 Gutenberg –Richter law

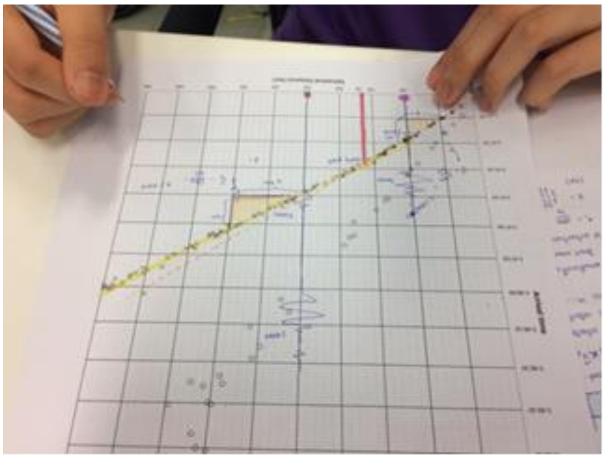


Figure.6 Travel time curve (Moho discontinuity)

<Puzzle games (hand simulations)>

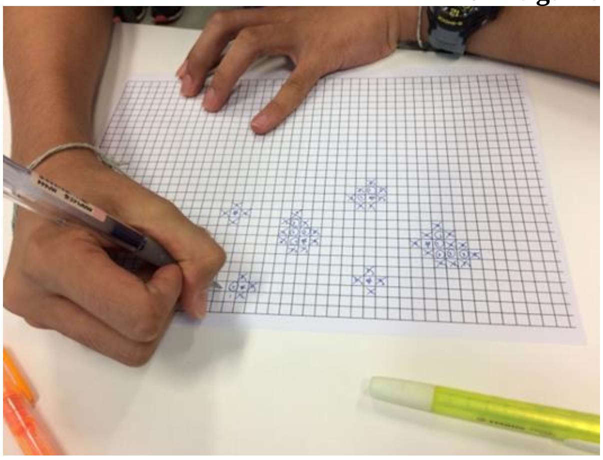


Figure.7 "Go-game model" for earthquakes

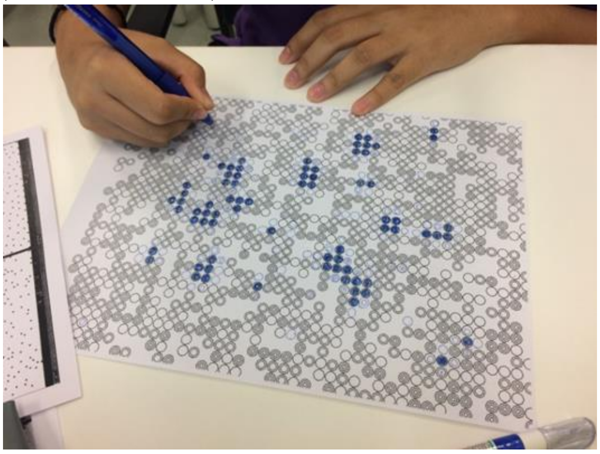


Figure.8 "Sand-pile model" for earthquakes

<Table experiments>

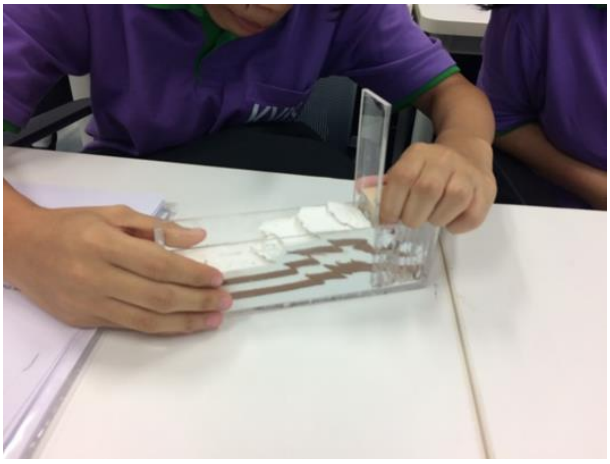


Figure.9 "Flour and cocoa fault" experiments (Okamoto, 2003)

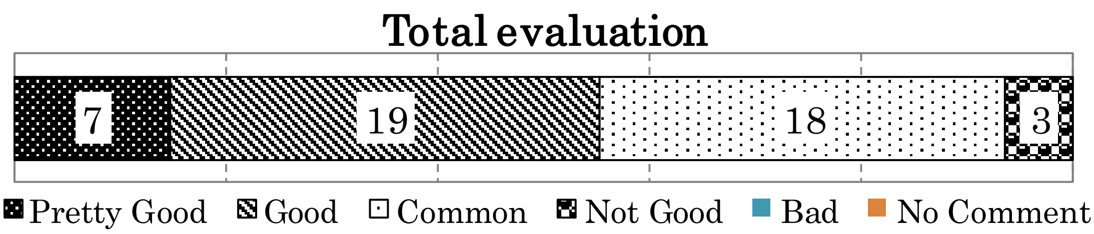
Figure.10 Thermal remnant magnetism of a basalt

6 Evaluation of the ESR course

6.1 The total evaluation of our course by the students

At the end of **the ESR course**, we gave a final questionnaire to each KVIS student (response rate 69%).
The result of the final evaluation of the students is shown below. It should be noted that some students are absent so the total number is less. Also the final question is only shown),

More than half of students evaluated our ERS course as "good" or "pretty good". There were only three students evaluated the course as "not good". There were only three students evaluated the course as "not good". There were no students expressing opinion on the course as "bad" or ticked "no comment". This is a registered questionnaire, so some flatters were included. However, the overall result showed a positive evaluation for our ESR course.



6.2 The most interesting topics by the students

The numbers of students, expressing opinions regarding the most interesting topics, are ranked in the following order of preferences:

Earthquakes related:	*14*
Dinosaurs and fossils (including paleontrogy):	*8*
Climate change (including "snowball earth"):	*7*
Rocks and minerals:	*6*
Mathematical models:	*3*
Volcanoes and eruptions:	*2*

The following topics, plate tectonics (including continental drift theory) and earth's interior, were not chosen as the most interesting topics

6.3 The comments for ERS course by the students

Examples of comments from students regarding the ESR course are shown below:

<Positive comments> [sic]

1. "It is your first time teaching foreign students in English. I am very impressed by your teaching skills. This is my first time studying ERS and it has really moved me, I believe it is mainly because how and what you teach. I will definitely look more into the contents, seems how close we are to the subject of understands our world"

2. "I love your teaching methods, you have a lot of easy tasks for students to follow to understand the concept, for example the log-log plots, cell automaton, and rocks observation. I like when you share your experience when you traveled around the world; they were very fun. Hope to seeing you soon. Thank you."

3. "I have new contents of earth science that I have never known before. The picture and details are interesting. Too much classes per one week. Would like to learn more about rock & mineral compare to seismic graph. Thank you so much for two months of this earth science class. And sorry for sometimes sleeping. You are good teacher and put an effort to teach us."

4. "Tell me about your trip, I love to listen to you talking about it."

<Negative comments> [sic]

1. "Actually your learning agenda is very interesting, but with the graph(difficult to understand), your slide looks difficult to understand. We, as a Thai students, have never learnt about this topic as you have taught deeply. Therefore, it is hard for us to be familiar or can catch up in your contents."

2. "Many topics are the topics that I think we don't need to know like earthquake which too much deep in details and I cannot use that knowledge. I think we should study the way to survive when earthquake occur, it could benefit to our life."
3. "I think this course is too detailed and memory intensive. The amount of information both in the sheets and your lecture is too much to wrap my head around."

4. "Some topics were quite hard to understand. More examples or exercises should be given."

Actually, the negative comments suggested that our power point slide contained a lot of materials. Also, some topics such as earthquakes and volcanoes are not popular in Thailand. These negative comments are quite useful for us to improve our course next year.

7 Discussion

This ERS course has a lot of contents on earthquakes and volcanoes the phenomena of which are rare in Thailand. So, the disapproval comments such as shown above are of course expected by the Japanese visiting teacher. However, for him, this is the first trial in Thailand to teach earth science. It can be inferred, therefore, that using these natural disasters as parts of major themes in composing an earth science course similar to those of Japan or the US, where the earthquakes or volcanoes are quite common in these countries, has been somewhat really a challenging trial in the Thai context.

Thailand is a lucky country where earthquakes are rare (Yoshio Okamoto, 2017, maps of earthquakes in Asia-Pacific from 1975-2016) and practically there is no volcanic eruption of the recent past. The results show that some students felt a strong positive impact from the course, thus expressing interests with these contents. This results show some trade-off and a difficult problem for earth science education in a country with low degree of occurrences of natural disasters. This is a big issue for teaching earth science in continental countries such as Europe and Southeastern America. So, we have to learn about the same challenges in such countries. We are very welcome to these suggestions.

Also, the challenge of teaching modern themes such as early earth or climate changes are divided among the two evaluation outcomes as good and bad. Because these issues need more basic knowledges about the earth and science, so some students were confused with such themes. A point worth noting is that students sometimes could not understand technical English terms, so they frequently needed to use their smart phone dictionary.

8 Conclusions

Even though there are always rooms for improvements, the conducting of the ESR course in Thailand as described is unique and challenging in the following aspects:

1) It was an attempt to teach high level earth science to the science-oriented high school students in English.

2) The class carried out by a co-operation of a foreign visiting teacher, a Thai counterpart teacher and an adviser.

3) The contents and curriculum are new and unique, and are quite different from the common traditional methods.

4) The purpose of the initial plan was almost successfully completed.

9 Look into the future

For next year, the Japanese visiting teacher will be able to stay for a longer period of time, so the time schedule of our ERS class will not be so tight compared to the current year. We have been preparing for the improvements of our ERS course both in curriculum and contents.

Also, this year we could not carry out field trips due to the limitation of time and space, but next year we will take students to geological outcrops. For this purpose, we have already checked a few geological sites not-to-far from the school for field trips. Our school has an SEM (Scanning electron microscope, Hitachi TM3030 Plus) equipped with EDX (Energy-dispersive X-ray spectroscopy) that can well be used for earth science study and research. We have tested it out successfully and plan to use the SEM-EDX for the mineral identification as well as the fossil characterization. Particularly, the radiolarian cherts are common in Thailand, so students will have chances to work on micro fossils identification using the SEM-EDX with the help of the KVIS adviser.

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