Practices-based Geoscience Special Classes at Thailand SCiUS High Schools

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Abstract

The author implemented practical (hands-on) exercises, experiments, and observation- based special classes for Thailand SCiUS high schools, focusing on geology and seismology. These schools, managed by universities, typically lack compulsory geoscience subjects, occasionally incorporating some geoscience knowledge into other subjects like geography. The teaching materials used in the classes, particularly seismographs, seismicity maps, flour fault experiments, and the rock thin sections for geology study, are the author's own made and based on real data and analog models instead of the digital or virtual resources which are now getting more popular in education. As a result, introducing full-fledged geoscience classes was a novel experience for the SCiUS high school students. The medium of instruction, English, and the non-native Japanese lecturer added uniqueness to the learning environment. Field excursions for geology and geography studies were also organized. The lecturer faced several new challenges, with differing class menus and targets across each school and a limited lecture schedule. Despite these constraints, the original teaching content was employed with minor adjustments, thanks to the full cooperation of the school staff. Nevertheless the tight schedule, student's enthusiasm for the lectures and excursions were palpable, with a firm grasp of the content. The evaluations from the student's feedback indicated a high level of satisfaction of the students. The results also revealed that the author's handmade teaching materials especially attracted the students' interest, and they were entirely fascinated by them. These experiences were not only valuable for the Thai students but also for the foreign teacher conducting the classes. Our findings underscored the necessity of further developing unique teaching tools and teaching methods in geoscience.

Keywords: SCiUS, high school, geoscience, exercises, seismogram, fault experiment

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Background

After my latest career in the Japanese high school and University, I had teaching opportunities in Thailand science high schools. Some of them have already been reported at conferences in Japan; for example, 1) At KVIS (Kamnoetvidya science academy) [1], 2) For Home School students [2], 3) For two PCSHSs (Princes Chulabhorn Science High School) are reported on my English website [3].

This summer, I was invited to some of the SCiUS (Science Classrooms in University - Affiliated School project) symposium 2023 at Thammasat University as a keynote speaker. During this visit, I was also invited as a visiting lecturer at the four SCiUS high schools to teach geoscience using my developed teaching materials. Some undergraduate students in science courses at universities are also lectured (Table 1). This visit continued for about one month, from the mid of August to the mid of September 2023. In this report, I would like to describe the details of my teaching. The schools usually have no compulsory subject as geoscience except some contents are taught in geography or another science subject. In addition, in some schools, the university staff teaches geology as a special subject (Chiang-Mai University Demonstration School).

Lectured SCiUS Schools/Grade

Table 1. Visited schools and teaching grades

Visit Days	Abbreviation	University	School name	Grade	Attended students
7	LW-school	Ubon Rachathani	Lukhamhan -warinchamrab School	M4 M5 M6 UD	88 + UD 25
6	SU-school	Silpakorn	Princess Sirindhorn's College	M4 M5 M6 UD	90 + UD
6	CMU-DS	Chiang-Mai	Demonstration School	M4 M5 M6	88
3	DeSUP	Phayao	Demonstration School	M4 (M5 M6)	M4 60

Lectured Contents

In those mentioned above, the schools usually have no geoscience class compulsory. Also, I have to visit four universities and schools in a very short time. Moreover, the teaching schedule and the target grades varied in each school. Therefore, I decided to reduce the contents from two categories: seismology and geology-related. These two categories have been lectured in English to Thai students, even science teachers, several times [1][2][3]. And I can compose the classes using only my developed teaching tools.

Earthquake-related contents

Seismograph mechanism demonstration

This demonstration shows how to measure ground motion with my hand-made seismograph [4], which consists of a pendulum and a couple of coil-magnetic sensors. Also, an amplifier + Arduino microcontroller shows a real-time wave display on a PC, demonstrating how to record earthquakes. At the same time, I lectured on the history of seismographs. The students can easily understand the fundamental structure of modern seismographs. After introducing the difference between the P wave and S wave, using a coil spring "Slinky", we present a nuclear test signal recorded by us at KVIS Thailand (see Figure 2A, B).

We discussed the difference between natural earthquakes and a nuclear test signal due to two different source mechanisms. This discussion will lead to our original flour fault experiment as a mimic of the reverse fault mechanism soon after.

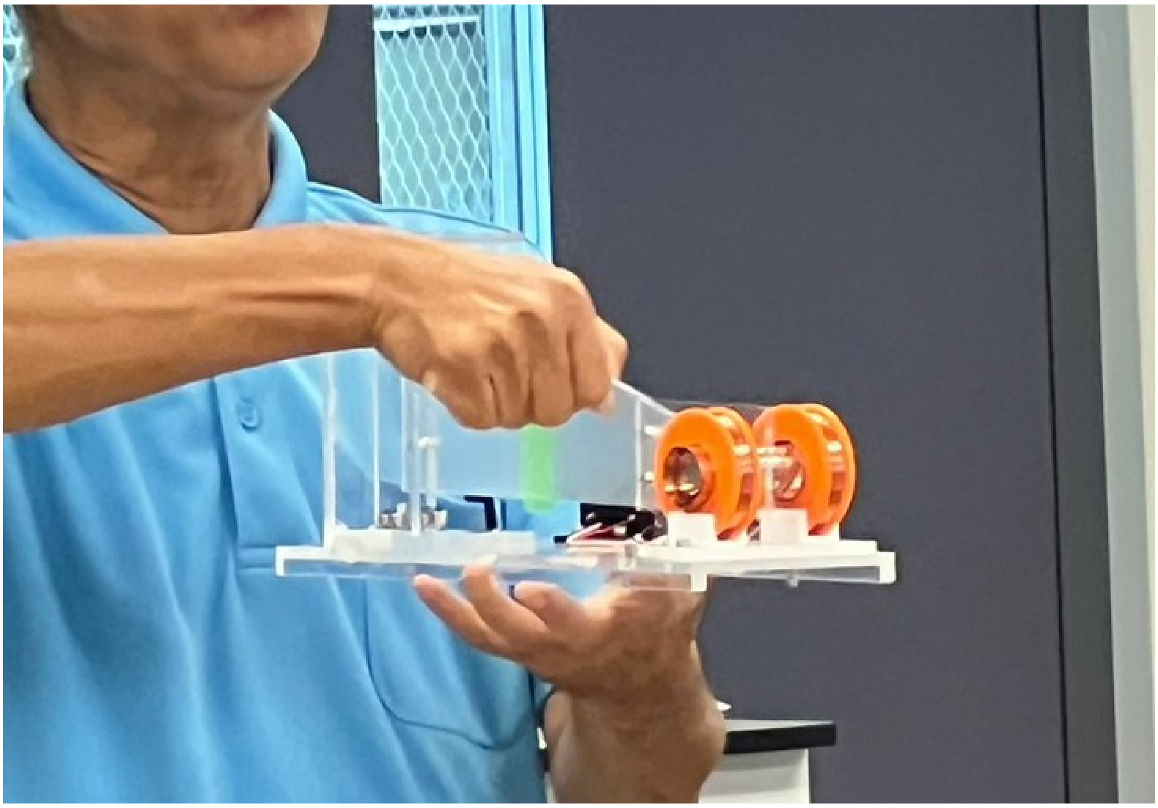


Figure 1: My hand-made “Skelton Seismometer” [4] to show the mechanism of seismograph.

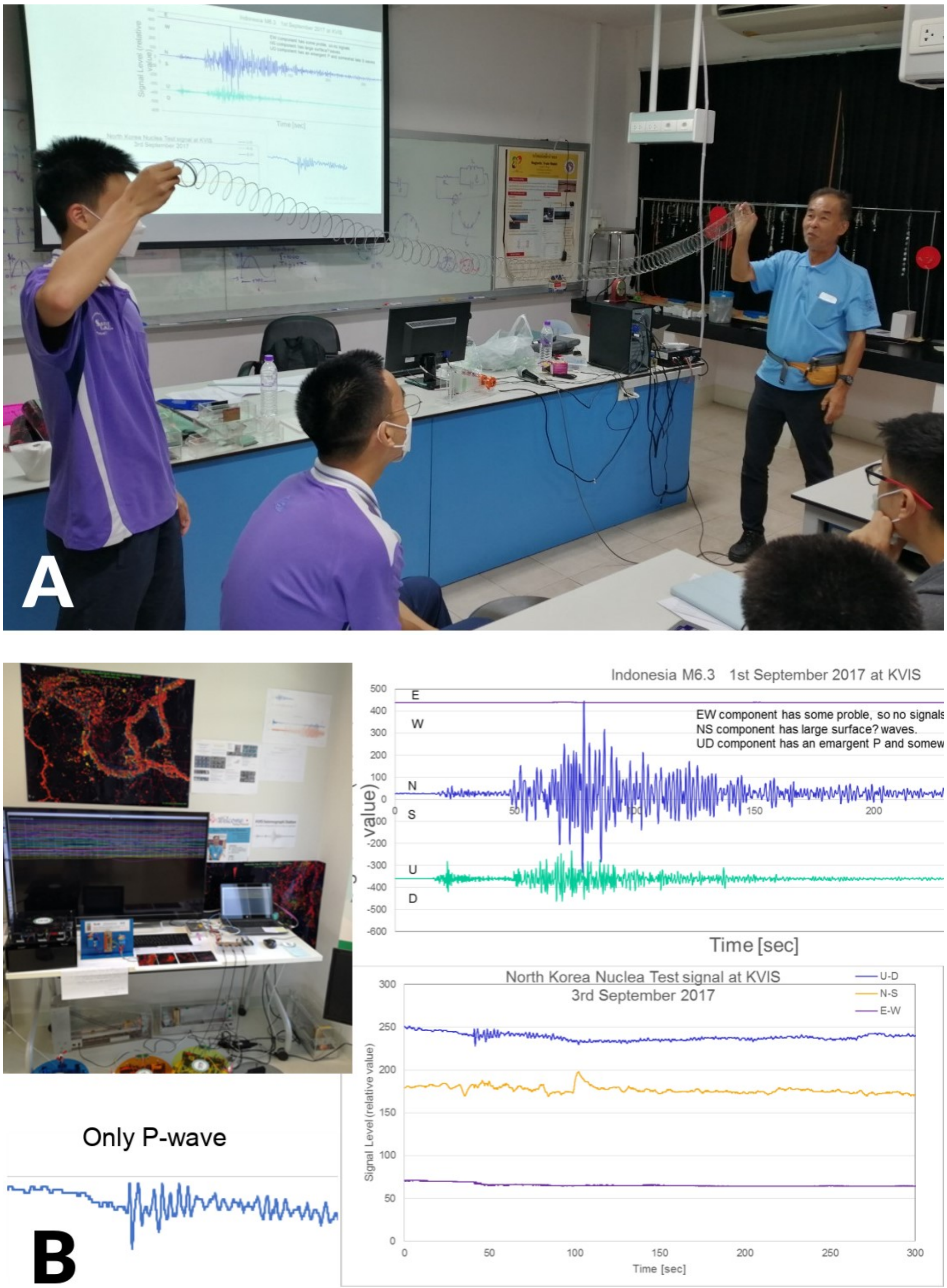


Figure 2: A. Showing the difference between P and S waves sing Slinky coil. B. The North-Korea nuclear test signal recorded at KVIS (Our hand-made seismograph system installed in 2017).

Seismogram analysis (finding an epicenter + calculating magnitude "Richter scale")

The exercise using the JMA (Japan Meteorological Agency) 59-type seismogram introduced how to use real seismograms to study earthquakes. The students tried to find the epicenter and depth estimation of the earthquakes, 1) derive S-P times, 2) calculate distances by Omori's distance law, and 3) plot three circles with a mathematical compass on a map [5] (Figure 3). Students carried out this practice with much curiosity. Moreover, if time permits, students can challenge the calculation of the magnitude ("Richter scale") of an earthquake. From the measurement of amplitudes of two horizontal motions and S-P time, they could easily find the answer on our original nomogram [5].

Their results show a good agreement with the catalogdata compiled by JMA. Students can understand how to use real seismograms and enjoy the exercise so much with satisfactory results.

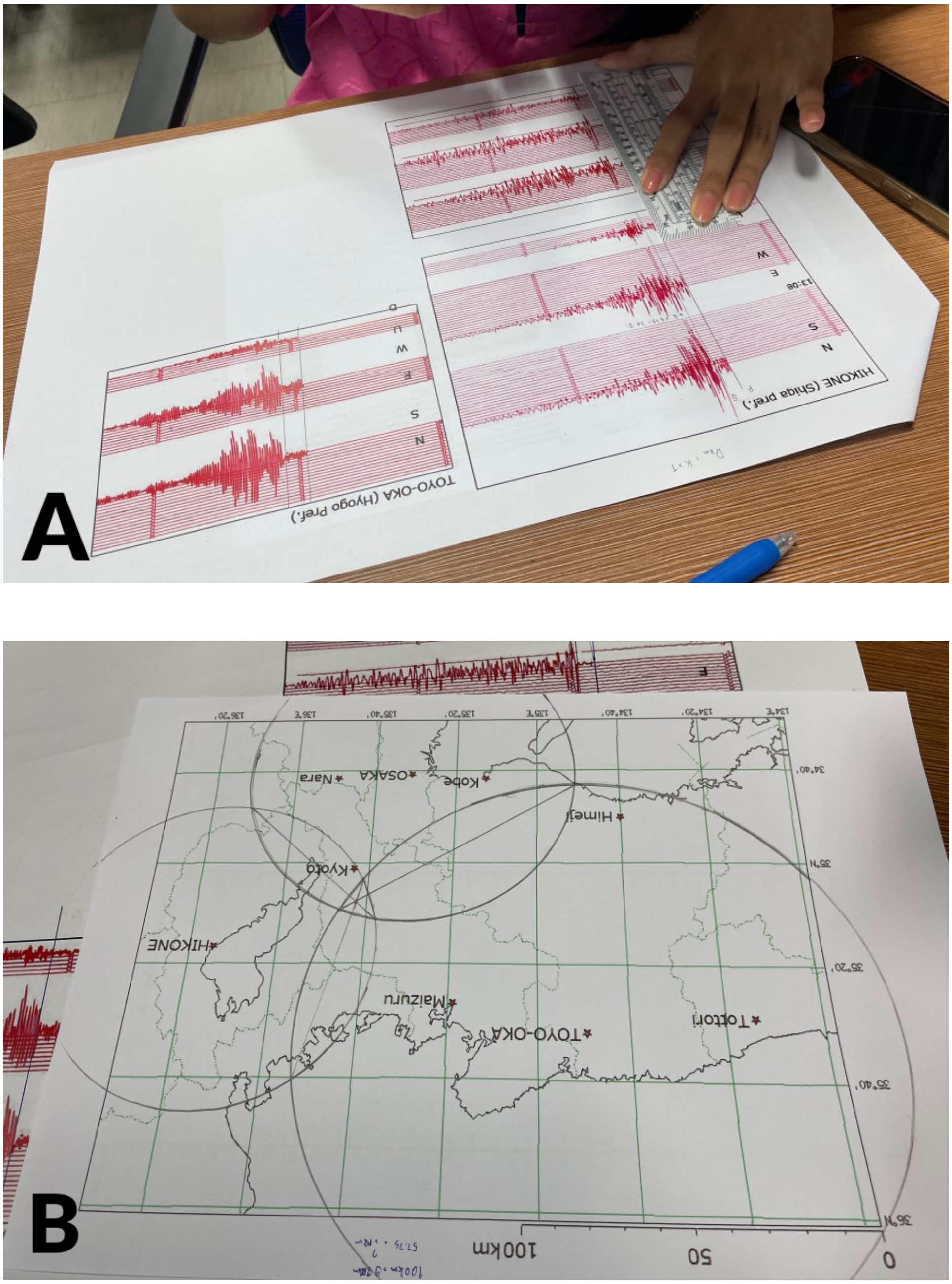


Figure 3: A. Student draws the lines of P and S wave arrivals on the exercise sheet. B. Then she draws three circles to find the epicenter.

Flour fault experiment and some discussion

This experiment shows the formation of reverse faults as the cause of earthquakes and mountain buildings. The students enjoyed making a mimic of geological strata inside of the plastic case. Three flour layers and two cocoa layers are enough. After completing, they observed the occurrence of the reverse faults by moving a push plate. The points of observation are 1) The order of the reverse faults; 2) The angles of the fault to the horizon; 3) The gaps of faults and sizes of dislocations.

After the experiments, we discussed the difference between the model and the natural world. This discussion is very important. 1) The answer is that there is no erosion (rainfall) in this model. 2) Where does its erosion energy come from? 3) The answer is from the sun. 4) The earth could be flat if only sun energy is present. Why are the mountains presented here? 5) So, they noticed the energy of the Earth's inner energy. However, what is the inner energy source? 6) The final answer is the heat from radioactive in the rocks and the trapped heat at the birth time of our planet.

Figure 4: 4A. Students show their flour fault experiment results in our original model, old-fashioned slide film cases (Silpakorn University Princes Sirindhorn's College). B. The reverse faults of flour and cocoa layers in a laser-cutter-made acyclic box (Chaing Mai University Demonstration School). This model experiment got the highest interest from the students during my classes; later, I will show an evaluation by our students.

Therefore, we concluded that such underground heat drives surface tectonic plates, and then we get many earthquakes, active volcanoes, and mountain buildings on the surface! Also, the inner energy drives Earth's magnetic field, which preserves our comfortable environment. This is the reason why our planet is still alive!

Such a short hands-on experiment led to the idea and the discussion about the whole earth driving mechanism, and they found the role of substantial natural energy and pondered our long-time geohistory.

Three-dimensional seismicity maps

The students observed 3D seismicity maps of Western Japan and South East Asia (including Thailand) using Chroma-Depth 3D Glasses [6]. They noticed the difference between the two regions, sited at a plate boundary (Japan) and the inside of a plate (Thailand). Also, they discuss the mechanism of 3D maps and the glasses as an exam of optical physics.

Figure 5: 3D seismicity maps of our own made [6] are watched by students wearing "Chroma Depth 3D Glasses".

G-R law on earthquakes and complex system

In my visit, most targets are high school students M4 to M6. However, in some universities, I lectured to undergraduate students. Here, I show the earthquake related contents, (for Silpakorn Univ. undergrad. And Phayao Univ. Demonstration School M4 students).

I presented the G-R law among earthquakes for a deeper study of earthquake behavior. This study consists of two exercises: 1) Plotting the G-R distribution of Japan earthquakes on a semi-log paper. 2) “Go game model as earthquake simulation [7]” playing to explain the G-R law behavior. This model, a kind of cell-automaton model like the famous “Life Game”, and modified as a classroom exercise by the author [8][9][10].

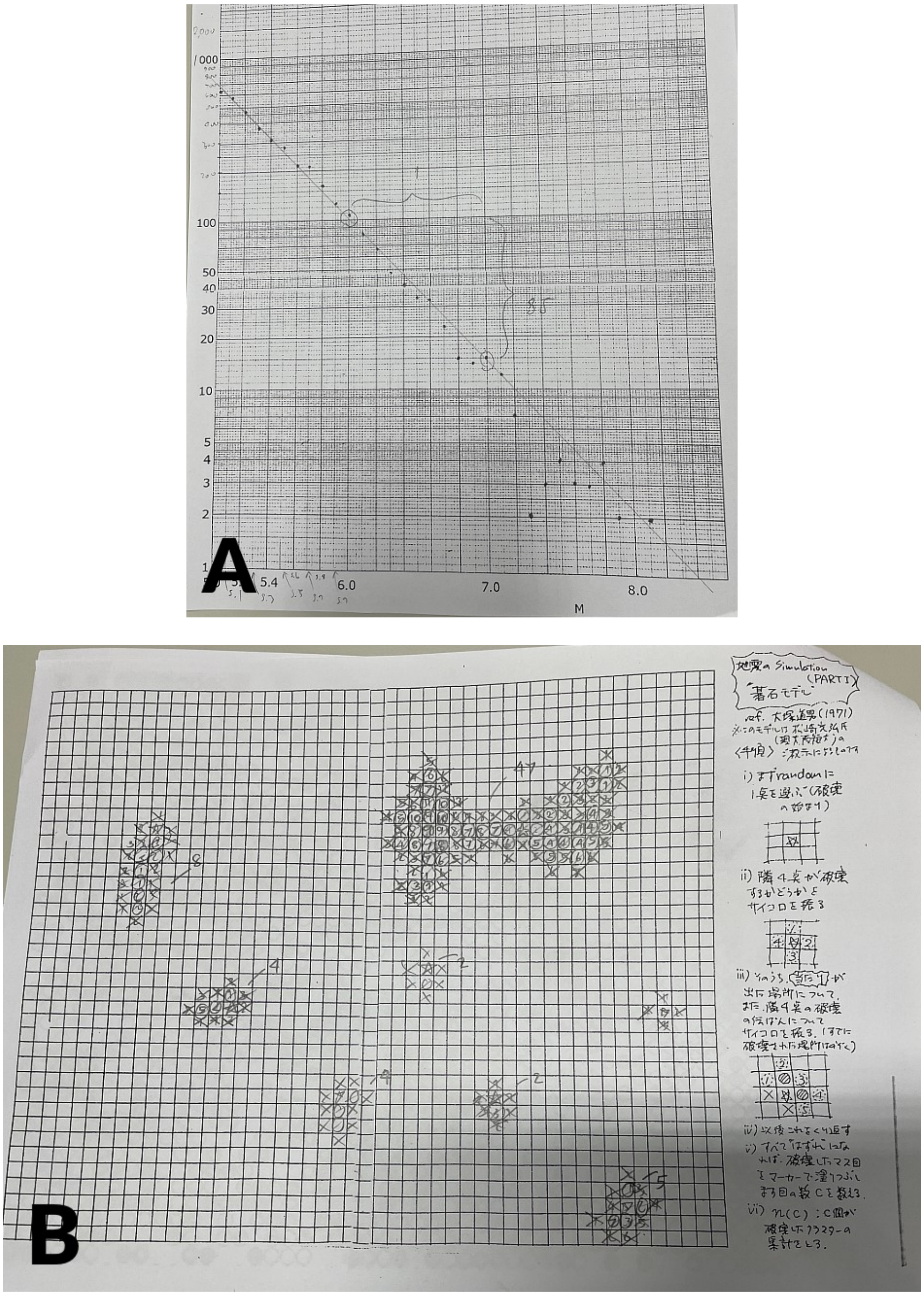


Figure 6: A. G-R law plotting on a semi-log sheet of Japan earthquakes from 1961 to 1999 (JMA data catalog). B. Go-game model playing exercise developed by the author [8][9][10]. This game is enjoyed playing by students on a grid-printed paper and using a pencil as a random dice. The results are gathered and plotted on a log-log sheet. The graph shows a similar G-R Law distribution.

Geology-related activities

During this visit, our lecture schedule was limited, so only a few exercises were presented for students in this category without field trips soon after they joined.

Thin-section and volcanic ash observation using a microscope + our original polarized unit.

The typical igneous rock thin sections were observed using ordinary microscopes and our original polarized units. The students were fascinated by these activities very well. All thin sections of igneous rocks and polarized units are my developed items [11]. Students enjoyed the observation and took photos using their smartphones. However, we emphasized the importance of their naked-eye observing. It was the first time for Thai students to watch a thin section under a microscope, so they enjoyed their observation by raising their surprised voices! The volcanic ash observation was also conducted; however, the volcanic soil sold in Thailand, which we used, was inappropriate for observing minerals under the microscope. The Japanese-made garden soil named "Akatama-tsuchi" is better to use for such observation.

Figure 7: A thin section under a microscope.

Other related contents

Exoplanet hunting (Astronomy related)

For the undergrad students (UBU), we lectured on an astronomy exercise to find the parameters of an exoplanet using NASA resources for educators [12]. However, this theme is far from the geology-related discussed here. So, we omit to describe here in detail.

What is science? (for DeSUP students)

In my past lectures for Japanese university students, Science fundamentals were always emphasized. So, I presented at the opening speech for M4 to M6 students about this theme. Also, I reported how to create science projects for high school students, which was the central theme of my keynote lecture at the SCiUS symposium in August this year. At the opening of my speech, two movies that feature volcanic eruptions were shown; the first was a real record of the eruption on 3rd June 1991 at Mt. Unzen volcano, Japan, which caused 43 deaths by a pyroclastic flow. Another was a computer graphics (CG-made) movie of the famous Vesuvius eruption in AD79, which buried the old town of Pompeii. In this speech, I strongly emphasized that science is based on real facts, not CG or AI images, now popular among the media such as YouTube. Also, I emphasized the importance of observations and experiments in getting scientific data through my other teachings during this visit.

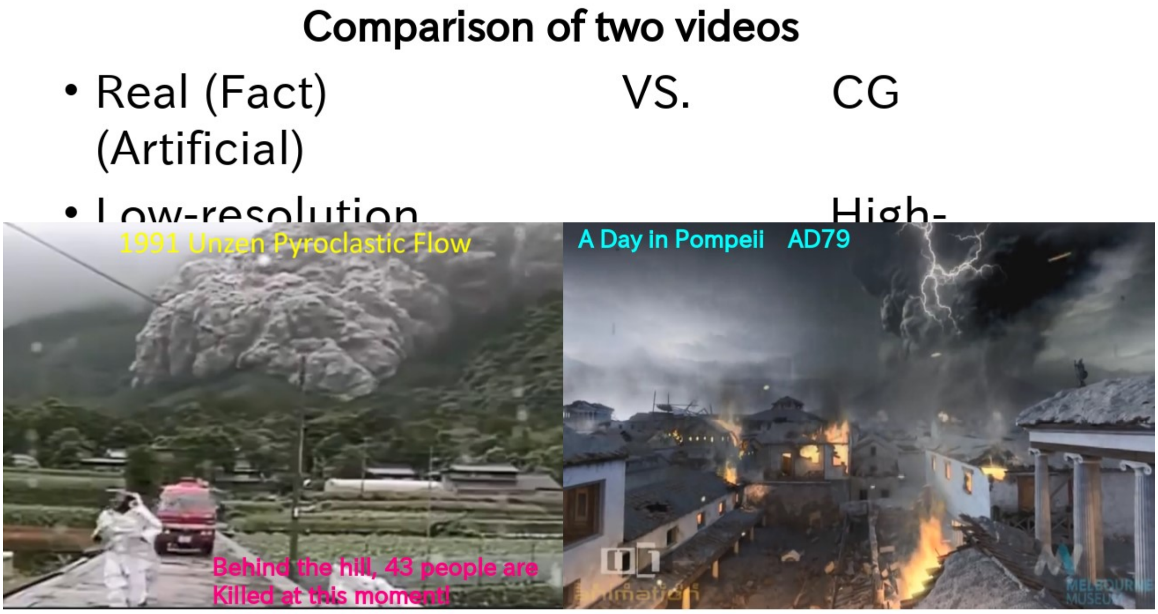


Figure 8: A slide from my lectured Power Point File. Students watched two volcanic eruptions videos, and they were asked, “What is the fundamental difference between the two videos”. The answer is the left is a real movie recorded by Mainichi Broadcasting System, but the right is CG made by Melbourne Museum. However, this question seems to be tough to answer for the students.

Geological Field Excursions

The SCiUS teams organized their field trips for geology, geography, and partly biology. The transportation is employed using their school bus or vans. Details are described in the image captions.

Table 2. List of Field trips (Locations etc.) NP: National Park, Mus: museum, MU: Mahidol Univ.

School	Location	Objective	Members	Guide
LW-school	Pha Taem NP	Hoodoo, sandstone layer, ancient art	30s + 6t	Dr. Sura, Author
LW-school	Phu Chong Na Yoi NP	Pot holes, water fall, plants	30s + 6t	Dr. Sura, Author
SU-school	N Kamchanaburi	Nautiloid DMR MuS stromatolites	7s + 6t	DMR staf.
SU-school	NW Kamchanaburi	Kamchanaburi Campus (MU) fossils	8s + 6t	Prof.Sashida, Dr.Kantanat, Dr.Apivut
CMU-school	SW Chiang-Mai	Pop up, hoodoo, oldest gneiss	4s + 3t	Dr. Burapha Phajuy
DeSUP	Lampang and Geo Museum	Limestone cave,cliff ancient arts, avtivities	58s + 3t	Dr. Chatchawai, Author

LW-school: two National Parks

LW-school visited two Cretaceous sandstone NP spots and stayed one night at a hotel in the NP.

SU-school: Kanchanaburi geology: Part1

The first fay: DMR Nautiloid fossil Museum and some fossil sites. The students also enjoyed walking at Seven Waterfall Trail and swimming in the river.

SU-school: Kanchanaburi geology: Part2

The second day: Permian marine Fossil sites guided by Mr. Kantanat (Geology department of Mahidol Univ.) in the vicinity of the Kanchanaburi campus. The students examined Permian marine sediments, mainly siltstone, and limestone, including brachiopods, sponges, corals, bryozoans, etc. (Figure 12A, B). Accommodation was on the MU Kanchanaburi campus.

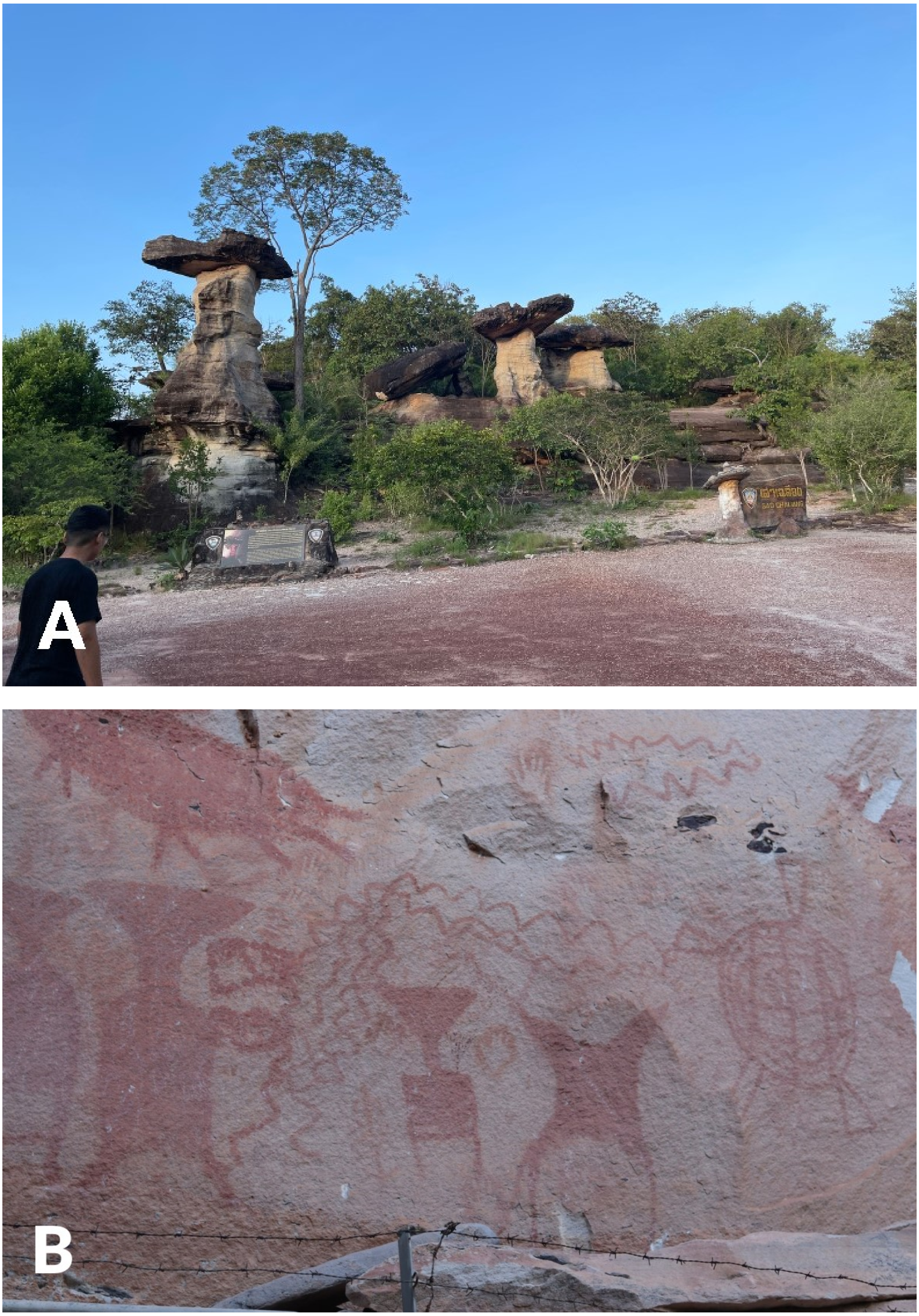


Figure 9: A. Hoodoos at Pha Taem NP. A famous sight-seeing spot. B. The students walked along the trail of ancient art 3000 years ago on a fluvial sandstone layer (Cretaceous age).

Figure 10: A. A waterfall at Phu Chon Na Yoi NP. B. A clear cross lamina was seen fluvial sandstone layer (Cretaceous age).

Figure 11: A. DMR Nautiloid Fossil Museum, the staff explained to us about the exhibits, particularly rare floating crinoid fossils. B. DMR museum staff guided Kradan Nautiloid Fossil site. They interpreted the network structure as stromatolites. C. An Ordovician Nautiloid fossil in stromatolites layer.

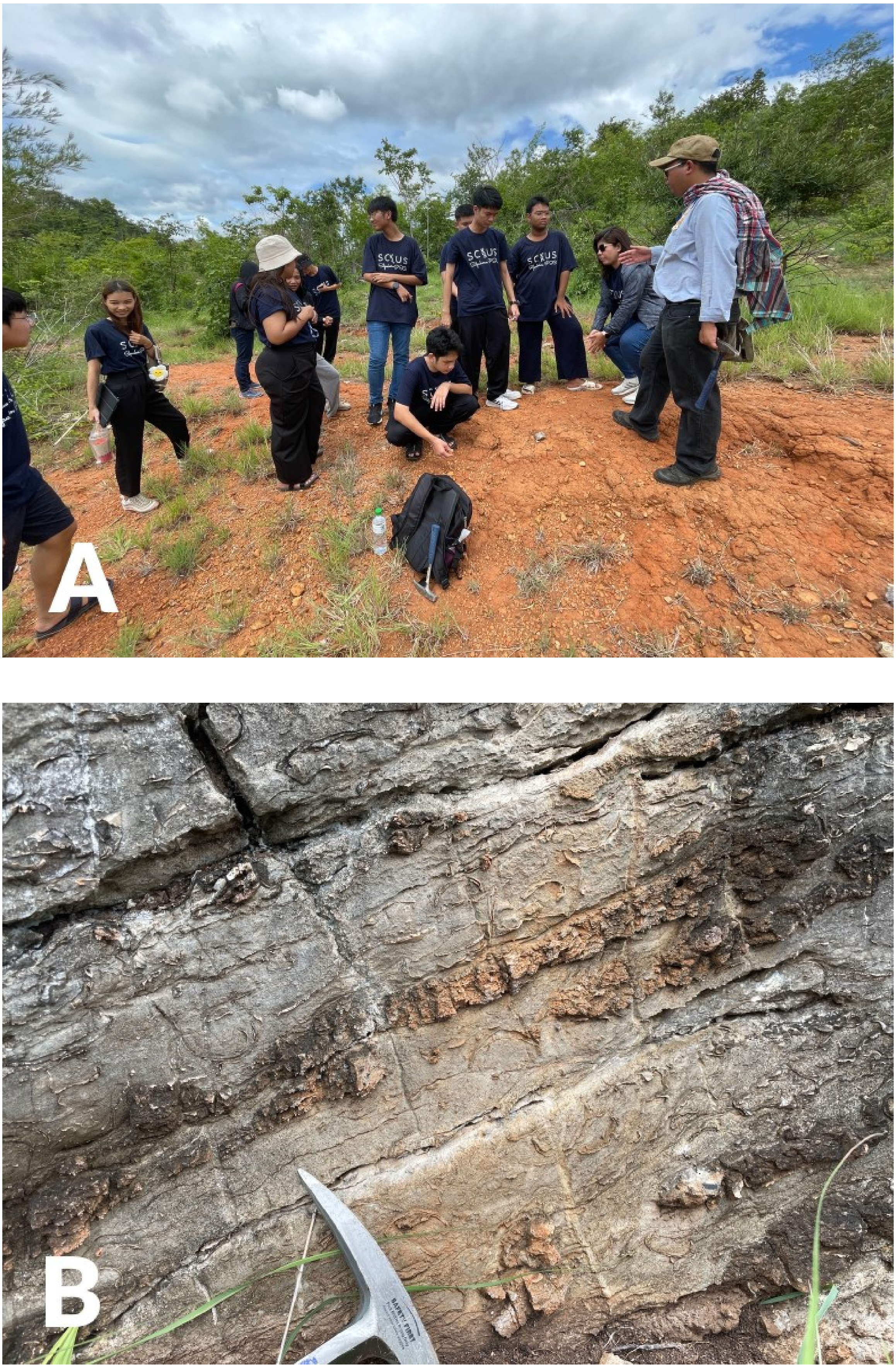


Figure 12: A. Permian marine fossil Site in siltstone layers and limestone layers near Mahidol Univ. Kanchanaburi campus. Mr. Kantanat explains the geology of his past study field. B. Permian marine fossil site: Brachiopods in limestone layers are seen.

CMU-DS: SW of Chiang-Mai City

This Excursion was guided by Dr. Burapha Phajuy (Department of Geology, CMU) Objectives: pop-up related to a Quaternary fault, hoodoos and erosional landscapes, gorge cut through the oldest metamorphic basements in SW of Chiang-Mai city.

Figure 13: A. Popup hill (Doi Noi, Doi Lo District) with “Pop-Up Structure in Chaing-May Basin “ between “Quaternary Strike Slip Fault”. Dr. Burapha Phajuy and students. B. Phachor (Mae Wang National Park) Erosional landscape with hoodoos. C. Ob Khan (National Park Gorge at Mae Khan River), the oldest metamorphic rocks as a basement of the mountains surrounding Chiang-Mai city.

DeSUP: Part1 A limestone cave and a cliff in Mae Mo District, Lampang Province

This one-day trip was guided by Dr. Chatchawal Wongchai (Phayao Univ. environmental. science). Objectives: Tham Pha Thai National Park limestone cave and a high tall limestone cliff with ancient arts.

Figure 14: A. Limestone cave at Tham Pha Thai National Park in Mae Mo District, Lampang Province: B. Dr. Chatchawal explained an environmental role of Tham Pha Thai National Park. C. High tall limestone cliff with ancient rock arts in Mae Mo District, Lampang Province:

DeSUP: Part2 Lampang Geology Museum

After the visit to the cave and the cliff, we visited the geology museum at Lampang. The students watched the exhibits and joined rocks and fossils identification activities. These were guided by museum staffs.

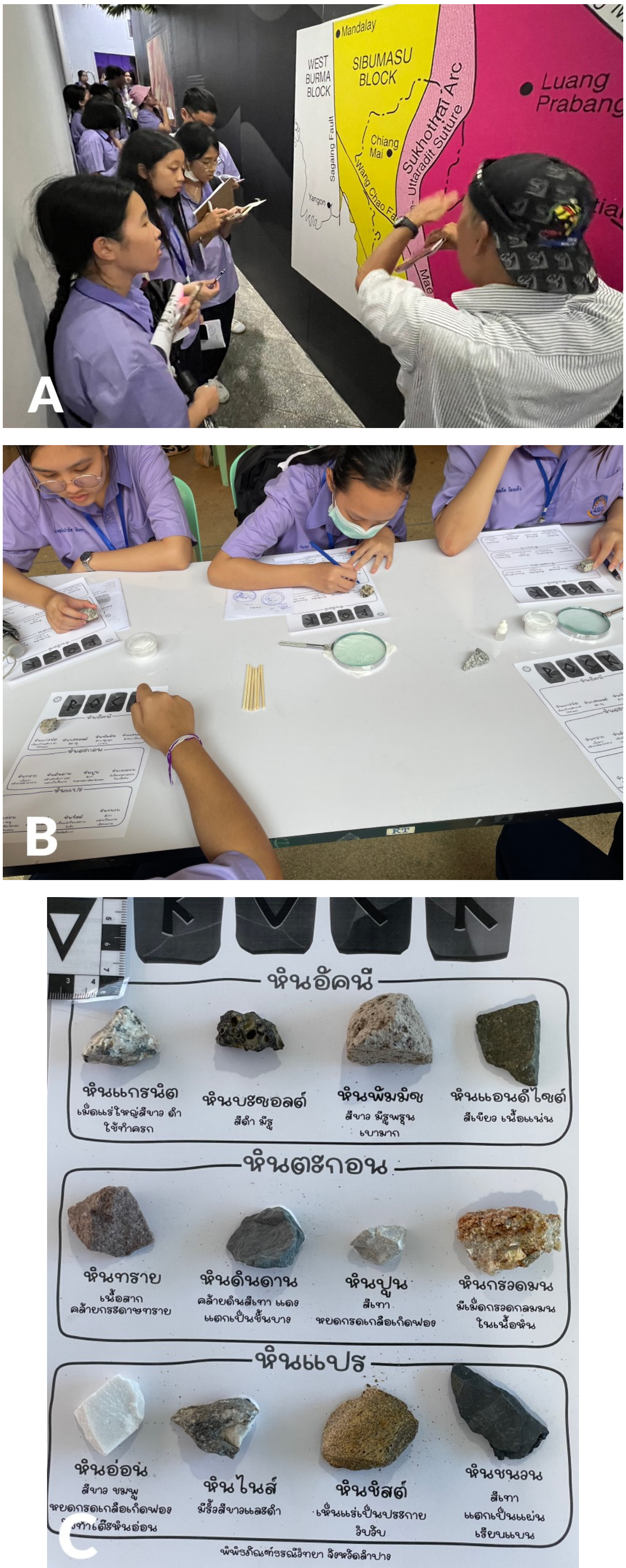
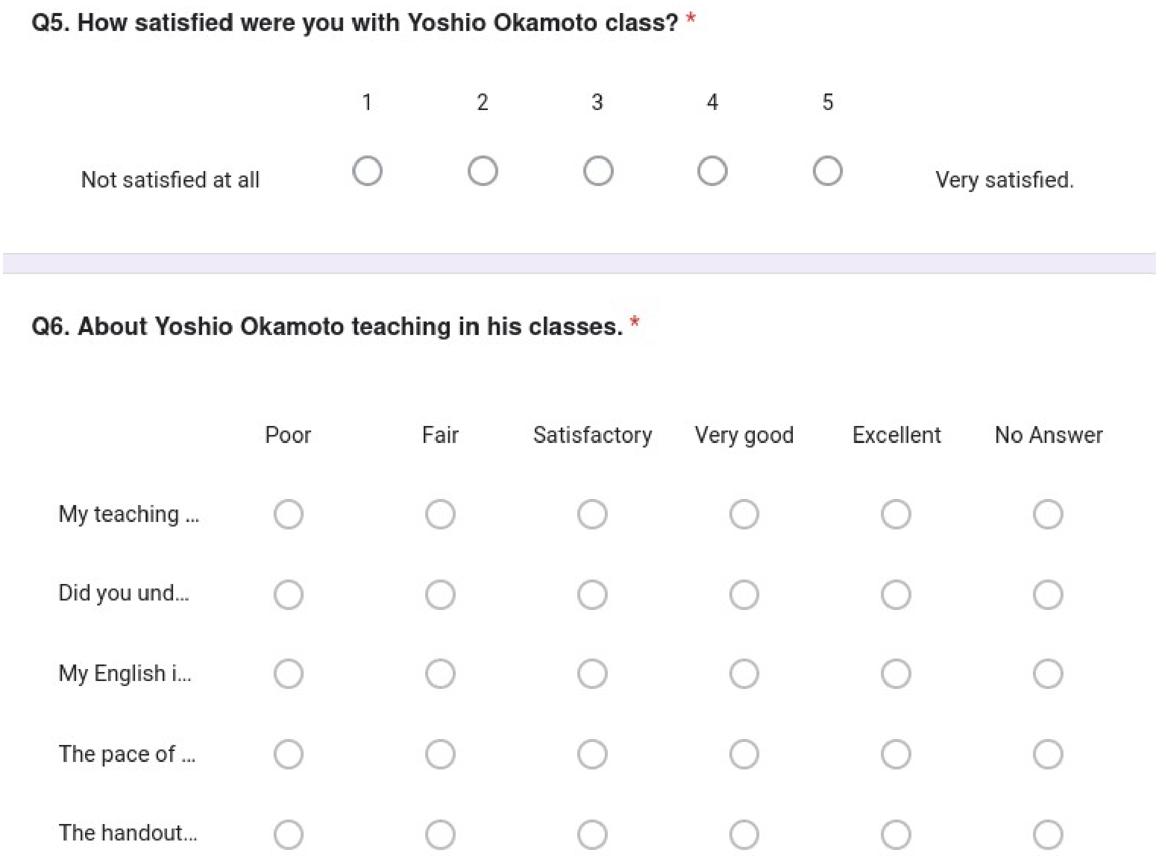


Figure 15: A. Museum exhibits were guided by the author. B. C. The rock identification activity by a museum staff. The students try to identify the rocks and link the rock names on a name sheet.

Evaluation

The feedback from the students of my classes was gathered using Google Forms half a month after my return to Japan. The total response rate is 80%. The whole results are as follows: (from Q1 to Q4 are not relevant to this paper, so these results are omitted). The results combined total student responses, not divided on their grades or schools. The core questions Q5 and Q6 are as follows,


Q5. How satisfied were you with Yoshio Okamoto class? *

	1	2	3	4	5	
Not satisfied at all	○	○	○	○	○	Very satisfied.

Q6. About Yoshio Okamoto teaching in his classes. *

	Poor	Fair	Satisfactory	Very good	Excellent	No Answer
My teaching ...	○	○	○	○	○	○
Did you und...	○	○	○	○	○	○
My English i...	○	○	○	○	○	○
The pace of ...	○	○	○	○	○	○
The handout...	○	○	○	○	○	○

Figure 16: Core questions and choices about our classes.

The results show strong positive reactions by the students for our classes. Particularly, teaching skills, teaching pace, and supporting resources. However, my English skill is not so appropriate for the students.

Figure 19 is the highest interesting content. This result shows hands-on experiments (flour fault experiment), our hand-made tool (seismograph), or hand-on activities (seismogram analysis) got high score of the student's interest or strong impression.

Figure 20 is "How about the field trip?" It is easily expected that the students like outside activities. Because they usually have no geology-related class. The field experiences are fresh and fascinating. This experience has made the study of geology more meaningful and exciting to the students. At the same time, an appropriate explanation in front of the scenery strongly helps with a deeper understanding of geology and our planet.

Even taking into account the students' thanks feelings, on the whole, these results show that the students evaluate our class much more positively. Also, many of the students who want to attend our class again are higher in numbers among the students, judging from the free comments of the questionnaire.

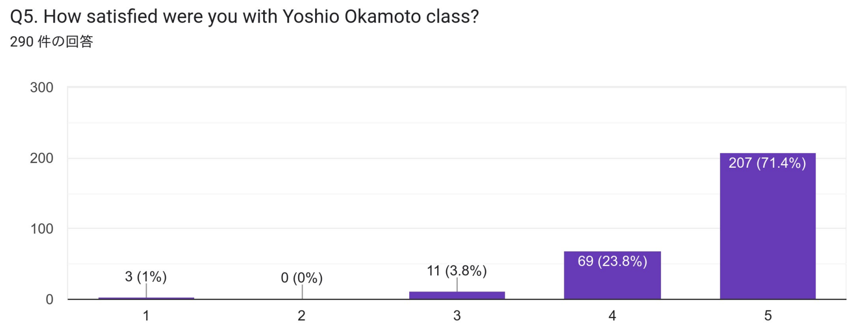


Figure 17: Total choices for Q5. "Very satisfied" is the highest.

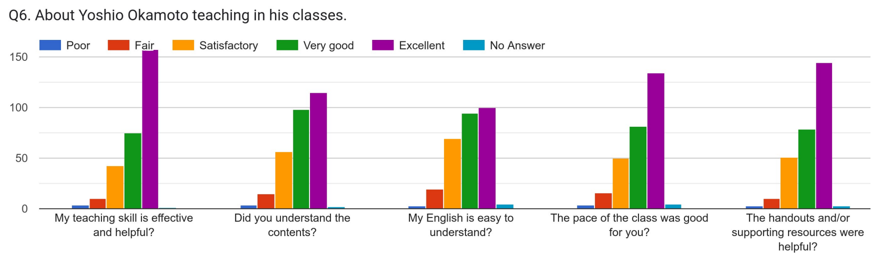


Figure 18: Answers for Q6. "Excellent" is the highest for all questions.

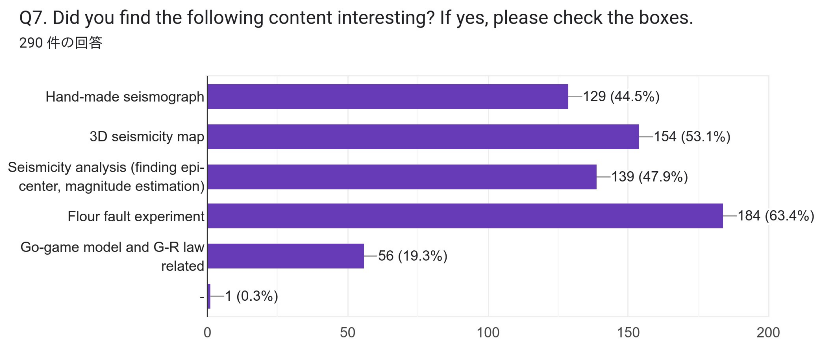


Figure 19: Answers for Q7. "Flour fault experiment" is the highest. Also, the own made tools or hands on activities got high score.

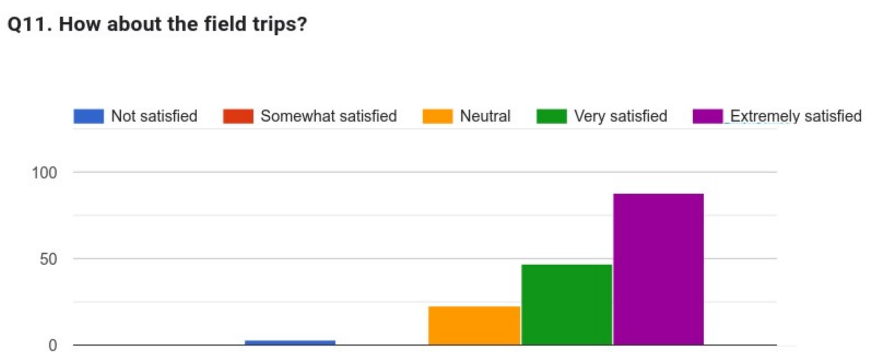


Figure 20: Answers for How about the field trip. Positive responses are clearly seen.

Discussions

The critical points of our classes are as follows,

For the students: never met environment

Many conditions are unique: 1) geology and seismology-related contents, which they usually do not learn from daily classes. 2) English-based lectures and resources. 3) Non-English native Japanese lecturer.

These unique educational conditions make students confused at first, but after they get more interest and motivation.

For the contents

I already have the experience of geoscience classes in the top-level science high schools in Thailand [1][2][3]. However, this visit had some new conditions. That is, each school has a different class schedule and grades. Therefore, we planned our classes as follows,

1) At first, I decided on the two core contents for every class; the first was seismograph demonstration and seismogram analysis, and the next was my flour fault experiment and some discussions. Because these contents have repeatedly been used in Thai science high schools by the author. And other contents were added as time allowed. 2) The teaching policy is that the classes are based on practical exercises by students instead of the traditional teacher-conducting lecture style. 3) Most of the teaching materials are composed of our developed original ones, such as handmade seismographs, 3D seismicity maps, flour fault. experiments, "Go-game" model exercises, etc. 4) No special or expensive tools are required. 5) Questionoriented (inquiry-based) teaching style and unique discussions are followed.

Feedback from the student

Feedback from the students indicated that they were extremely satisfied with my class, and they requested that my class be given again in their free comments. In this respect, the author's intentions were realized. However, students only did not give full marks for my English skills. This is the priority point to be improved, of course, rapid skill up might be difficult. However, these results confirm that the students have a very high ability in English senses, even though the lecturer was a non-native English speaker. At the same time, this result is surprising for the author. Because in the science high school in Japan, even top-level schools, it is very rare to organize the science classes lectured in English. So, the English level in Thailand science high school students now far surpasses that of their Japanese counterparts. The evaluation of the teaching materials used in the class was also very much appreciated, and we would like to further work on the development of teaching materials for the next goal.

Conclusion

The geoscience-related special classes and field excursions for science high school students were successfully carried out under a unique educational environment and with fully correspondent staff of the schools. Most of the teaching tools were originally developed by the author and brought the highest educational effect in the class. Although this initiative is new for teachers and students, the feedback results show that the lecturer got unexpectedly good student evaluations. Both the students and lecturer had unique experiences and enjoyed the courses. These experiences will guide new paths in geoscience education in Thailand and other countries.

Acknowledgments

The Thailand SCiUS university and high school staff, particularly, Dr. Pornrat Wattanakasiwich (Chaing-Mai University), Dr. Sura Wuttiprom (Ubon Rachathani University), Dr. Sumonmarn Chaneam (Silpakorn University), Mr. Manus Poothawee (Director of SCiUS University of Phayao), Ms. Paililn Limwattanachai (SCiUS office). Also, many teachers of SCiUS high schools helped with my class and field excursions. Moreover, they helped a lot in the preparation for my exercises, particularly the flour fault experiment. Some schools already made their own plastic boxes for the experiments. In the field trip, Prof. Katsuo Sashida, Mr. Kantanat Trakunweerayut and Dr. Apivut Veeravinantanakul (Geology department of Mahidol University), Dr. Burapha Phajuy (Department of Geology, Chiang- Mai University), Dr. Chatchawal Wongchai (Phayao University) guided our school excursion. Ms. Madoka Inui (Tennoji Senior High School attached to Osaka-Kyoiku Univesity) discussed how to use Google Forms. Dr. Thanit Pewnim facilitated me to visit the SCiUS symposium and

Thailand's high schools. Also, his helpful suggestions on my draft contributed greatly to improving this paper. I would like to express my deepest gratitude to all of them.

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