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Learning Archaeoastronomy in Temples with STEM-focused Mobile Learning Approach

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Abstract: Ancient people during prehistorical time constructed their knowledge based on observation and recording then kept it on archaeological site. Young generations are trying to understand the secret of historical site which was called archaeology study. In Thailand, there are many temples and that temple may keep ancient astronomy knowledge. However, there are not many scientists who are interested in archaeoastronomy in our country. Our research focused on mobile learning approach which is proposed to enhance Archaeoastronomy activity with STEM-focused in historical field. The activity was designed based on STEM activity. Science and Math were applied on astronomy topic. Technology was applied on mobile learning and Engineering was applied on drawing and scaling. Additionally, mobile learning was used to support all STEM activities in field because of astronomy mobile applications are widely spread during 21st century. The results showed that students can learn more in field when use mobile supporting in STEM activities and soft skills such as critical thinking, questioning and problem solving were use during this activity. The research could challenge teachers who appreciate STEM education to apply more archaeoastronomy in their historical site around the world.

Keywords: Archaeoastronomy, mobile learning, STEM Education

1. Introduction

Thailand's considered as an enrich multicultural country in Asia. Owing to their location, and territory, they recognized to situate in the central of Southeast Asia, the most important ancient trade's route in Asia. It's considered as the pathway between Western to Eastern. Therefore, Thailand remains a significant civilization in the World history until nowadays. Many historians annually came to Thailand in order to study Eastern civilization history from the historical evidence in the historical site, such as, Sukhothai historical site, Ayutthaya historical site, and others sites in this country. Hence Thai history was not only be significant in the context of domestic Thai history education, but also be significant in the World history education.

Thai history course is a required course in every school in Thailand. According to Ministry of Education, Thai history is a significant course which is be merged as a part of Social studies, Religion, and Culture subject. Students have studied this course since Grade 1st until Grade 12th. Nevertheless, there are some limitations studying history because rote learning is the main method of learning Thai history both in the lecture class, and in the field. In addition, they weren't integrated with others Science. From these limitations, students were rarely trained and develop the critical thinking, creativity skill as expected.

According to the limitation of Thai history education, learning beyond class's considered as a learning method that could improve those limitations. Archaeology is an effective learning approach supporting historical education in the real place. It could collaboratively connect knowledge content in the lecture class to the historical site. Moreover, it could accelerate learning behavior to integrate with others Science, such as, Astrology, Geography, Geology, Geometry, etc. Archaeoastronomy is

one of the integrations between archaeology and astrology from the ancient civilization. Ancient people from prehistoric period may possible connected the monument of Stonehenge with ancient astronomy. The researcher discovered that Stonehenge is aligned in the direction of the sunrise of the summer solstice and the sunset of the winter solstice. In Thailand, Sukhothai Historical Park's considered as a World Heritage Sites by UNESCO. In this World Heritage composed of the city's walls form a rectangle about 2 km (1.2 mi) east-west by 1.6 km (0.99 mi) north-south. There are 193 ruins on 70 km^2 (27 sq. mi.) of land. There is a gate in the center of each wall. Inside are the remains of the royal palace and twenty-six temples, the largest being Wat Mahathat. According to their ancient complete city, it's quietly appropriate for learning many subjects through this ancient city. Students could collaboratively integrate History with Astrology through the city building that connected with Moon orbit, and Earth orbit around the Sun absolutely associated with Temple building.

In field trip, mobile learning is very helpful when the student do not know something then they can search immediately or when they are interesting in something then they can take a photo for recording the evidence which is fascinated by them. Our study designed the STEM activities that related to archeoastronomy and mobile could help supporting the more active learning during in field situation. The more active, the more inquire knowledge may happen. Recently, astronomy mobile apps have developed widely and turns mobile device into a mobile planetarium. It is very easy to our student to find out the relationship of temple construction and sun position which was based on the belief of ancient people.

Therefore, the integration between history, STEM and mobile learning from our research would show some different way of learning history if compare to normal Thai education system. Student's competency may increase due to the enhancing of their soft skills such as critical thinking, creative thinking, questioning and problem solving. The aim of our study is to introduce the new integration pedagogy between STEM activity and history topic using mobile learning approach.

2. Archaeoastronomy and STEM-focused Mobile Learning

Archaeoastronomy is ancient astronomy which explains about the construction of ancient sites based on the observing of regular cycles of the Sun, Moon, planets, and stars in the sky for agriculture including creating a calendar. Archaeoastronomy suggests maybe one of the best means of understanding certain cosmologies of people during ancient civilization. Not only have anthropology and history consistently revealed that celestial phenomena are of "almost universal concern" (Ruggles 1999:83). For example, Thornborough monument complex in Yorkshire's North Riding may have intentionally referenced the midwinter sunrise, Orion's Belt, and other celestial events. These relations might have simulated the seasonal changing of those using the monument complex, thus proposing a close connection between people's skyscape and life cycles during Neolithic period (Harding, Johnson, & Goodrick, 2006). Ancient astronomer from Suvarnabhumi civilization linked the cycles of sun and moon for its association with agriculture especially rice. The Suvarnabhumi people were able to develop a calendar that matched with the seasons by observing and recording natural phenomena surrounding them. Moreover, they can precisely observed the particular angles of sunrise at south solstice (23.5° S), equinox (0°), and north solstice (23.5° N) using their own calendar (Saelee, 2018).

In this current, mobile learning is widely considered by many educational academicians as the blending of mobile computing and e-learning comprising of accessible resources. Students can search for the data anytime and anywhere you are. Baran opined that mobile learning could be an effective accessing learning approach in this period (Baran, 2014). Nevertheless, mobile learning perspectives still based on the traditional learning method which blending with the mobile device. In the present, learning are not only limited to lecture-based learning, but mobile learning could assist the students to collaborating knowledge content by exploring the real world and the virtual world (Shih, Chuang, & Hwang, 2010; Vishwakarma, 2015). According to Chatterjea (2012) created NIEmGeo, the app allows students to geo-tag data like text, photos, and videos onto a shared map for Geography field.

Mobile learning's considered as a necessary learning approach inevitably because nowadays, learning didn't limit not only in classroom (traditional learning), but also appeared in online database. In addition, STEM was also recognized as an effective approach to accelerate learning behavior. Hence there are many study that blending mobile learning in order to support STEM education as follow,

Krishnamarthi founded that mobile learning could accelerate student from underrepresented group to get better learning performance in STEM activity (Krishnamurthi & Richter, 2013). Similar to Ariffin, founded that mobile could developed some skill using the multimedia function of mobile phone (Ariffin, Side, Fadhil, & Mutalib, n.d.). In case of the collaboration skill, Grimus opined that qualified STEM educator had an important role to develop learning approach (Grimus & Ebner, 2016). According to Razak, he founded that lack of motivation, and lack of qualified STEM educator is the main hindrance for STEM education (Razak, Strategy, Through, Usage, & Technology, 2015). Therefore blending mobile learning with STEM education could accelerate learning behavior (Thibaut et al., 2018).

It seems like archaeoastronomy is the STEM education itself so it is challenging for teacher "How to apply this field of study into Thai history learning?" Nowadays, mobile apps are widely spread and very easy to monitor celestial real time in field so if we can apply mobile learning into STEM activity but answer the history questions. Science's students might be focused and concentrated more when studying at historical field. To implement all ideas, teachers designed and mocked up activity first, then use develop lesson plan to test with students in real situation.

3. A Novel Learning Approach and Learning Process

3.1 Research context

The activity is under subjects called "ESC 421 The builder and ESC 422 The Navigator" of Engineering Science Classroom affiliated by King Mongkut's University of Technology Thonburi (ESC-KMUTT) in the 2nd semester of 2018. These 2 subjects are the integrated subject under Story-based learning curriculum. ESC-KMUTT has been used Story-based learning as its curriculum for more than 12 years for nurture the innovator, scientist and engineer. This curriculum is promoting high school students to learn through "stories" by which all learning topics are interwoven and integrated. In addition, thinking skills are taught such as critical thinking, creative thinking, visual thinking and scientific thinking.

3.2 Research Participants

The participants were 10th grade students form 3 classrooms (n=78) of ESC-KMUTT during 2018 academic year. Each group consisted of 6-7 students therefore there were 12 groups in total. All of them were past the first year of high school at ESC-KMUTT and were going to 11st grade in the next semester. The sample consisted of 38 male and 40 female students, at the age between 14-16 years old.

3.3 Methods

This research use Sukhothai historical park for an archaeological site studying during 2 days. Archaeoastronomy activity was designed based on STEM-focused. Science and Math were used in part of astronomy activity. The activities were sun shadow and sun position observation in Sukhothai historical park during 1 day. Engineering and Math were applied on architecture activities which were temple measurement and drawing top view of that temple based on engineering concept. All activities were work in field and use mobile to support learning while they were working or discussing among friends. The important mission was to find the relationship between temple building and celestial phenomena (Figure 1).

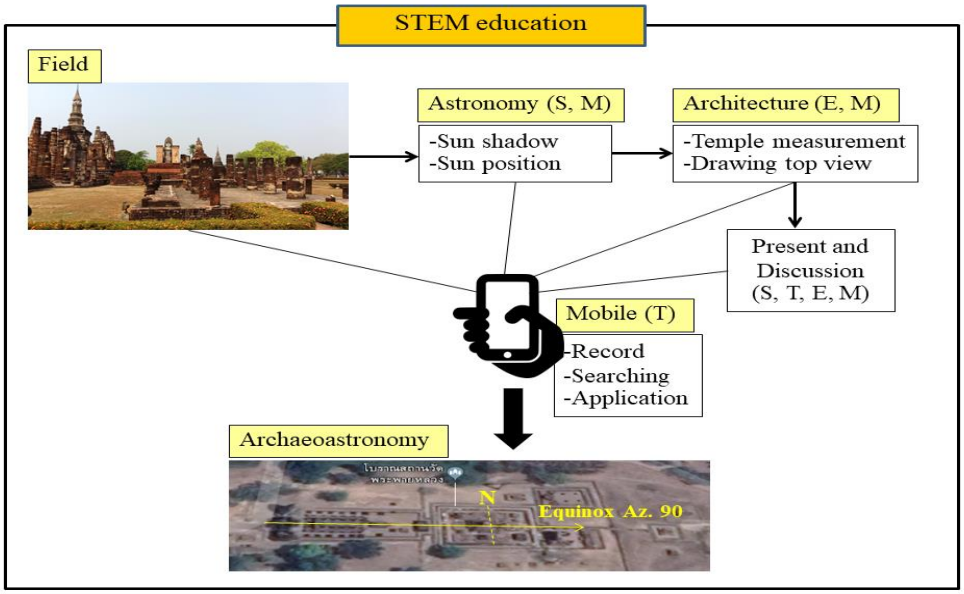


Figure 1. Conceptual framework of Archaeoastronomy activities.

For in field study, there are 3 temples that hypothesized to relate to astronomy observation in Sukhothai historical park. 1) Wat Mahathat, the main temple for Sukhothai empire ceremony which was built following the concept of Mandala, an ancient Hindu symbol representing the universe. 2) Wat Si Sawai, the temple consisted of three prangs which was constructed by the Khmer as a Hindu sanctuary dedicated to Shiva. 3) Wat Phra Phai Luang, the temple was built by the Khmer when the Sukhothai area was an outpost of the Khmer empire. It was the center of town in the pre Sukhothai era and the most important temple of that time (Figure 2). Every temple was measured and drawing its constructs that may relate to sun movement during one year (Table 1).

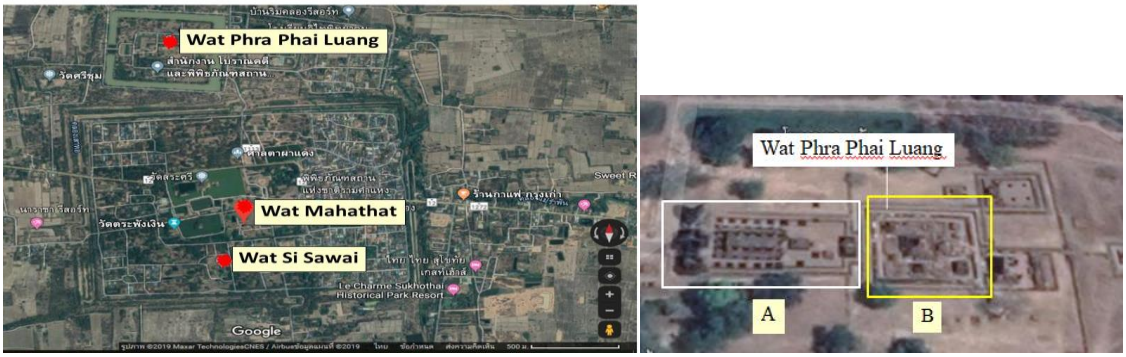


Figure 2. Map of Sukhothai historical park in field trip activity.

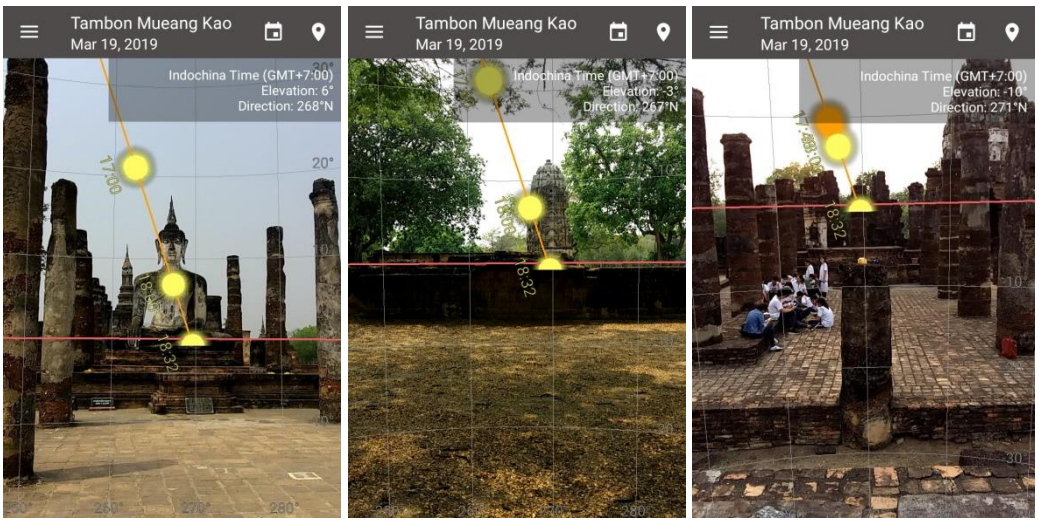
Table 1
Learning activity before and during a one-day field trip.

Activity	Description
Introduction (30 min)	1) Students studied the location of 3 temples in Sukhothai historical park by using Google map/ Google earth (10 min). 2) Students watched a video of Equinoxes which made by National Geographic https://www.youtube.com/watch?v=kaG6PTVrFP4 3) Encourage students to ask questions for seeking the relationship between temple building and sun position. Brainstorming and listing the used equipment for 15 min.

Activity	Description
Questioning (15 min)	1) Do students think that people in the past built temple to understand the beam of the sun? 2) What and Why, do ancient people want to know about the relationship between religious building and sun position? 3) How can we understand the knowledge of ancient people from their construction? 4) What do students learn from measuring of the shadow of the sun during 1 day?
Give assignment (15 mins)	1) What do students learn from measuring of the shadow of the sun during 1 day? 2) Students go to the field and measure the sun shadow in 1 day then record the observation. 3) Students measure the temple and draw a top view with scaling. 4) Discover the relationship between temple building and sun position using discussion, mobile application and search engine.
Field trip (9 hrs) A) Wat Mahathat B) Wat Si Sawai C) Wat Phra Phai Luang	1) Students study the 1st temple from 9.30-15.00. Group 1-3 study at Wat Mahathat and Group 4-6 study at Wat Si Sawai. 2) Students study the 2nd temple which is Wat Phra Phai Luang from 16.00-18.30. Group 1-3 site A and Group site B. 3) What time does the sun set at the observing day? 4) Where does the sunset compared to the 3 stupas at Wat Phra Phai Luang? Let's draw the picture.
Present (2 hrs)	Six groups of students present all their works on power point presentation for 10 min and discuss for 10 min.

Students were doing archaeoastronomy activity in field from 9.30-15.30. Firstly, teacher briefed about the activity again and gave them the equipment such as A4 and A3 paper, measuring tape, Scotch tape, plastic rope, compass and water ruler. Then, they were observing the sun position during one day and measuring the size of temple for scaling and drawing (Figure 3).

Figure 3. Field trip activity during 1 day at Sukhothai historical park.



A) Wat Mahathat B) Wat Si Sawai C) Wat Phra Phai Luang

Figure 4. The photos from Sun Position, Sunrise, and Sunset Demo mobile application.

Mobile applications were used to enhance learning in field situation. For example, Sun Position, Sunrise, and Sunset Demo app is the application for showing sunrise and sunset times, in addition to the solar and lunar path on an augmented reality camera view for any day of the year at our current location. Students used it for monitoring sun movement and sunset in the activity (Figure 4).

4. Experiment and Result

4.1 Experiment

Based on archeoastronomy activity during Sukhothai field trip, a record about student's work were collected and classified into some expected soft skills by teachers.

There were 80 participants from Engineering Science Classroom (ESC) batch number 10. They were divided into 2 main groups. The first group were studied on 19 March 2019 and the second group were studied on 20 March 2019. One main group were divided into six small groups (1-6). Sukhothai historical park group 1-3 were studying at A) Wat Mahathat, group 4-6 were studying at B) Wat Si Sawai during 9.30-15.00 (Fig. 2) after that from 16.00-18.30 they were going to C) Wat Phra Phai Luang. Group 1-3 were studying at zone A and group 4-6 were studying at zone B of Wat Phra Phai Luang (Fig. 2). Finally, everyone were sitting and seeing the sunset at Wat Phra Phai Luang.

The students were assigned to work during one day. All works were collected and present to peer and teachers at night time (20.00-22.00). The assignments are as follows:

1. Measure the angle from reference point to find out the relationship between temple construction and sun position.
2. Measure the size of temple and drawing the temple building.
3. Measure the sun position path in 1 day.

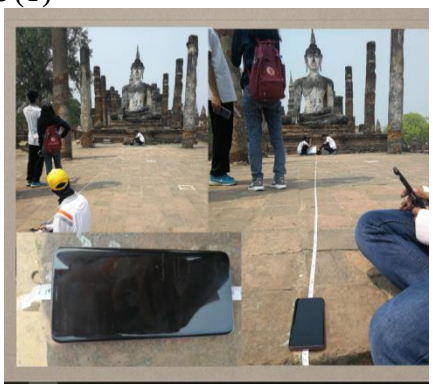
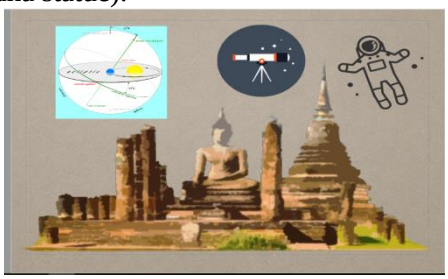
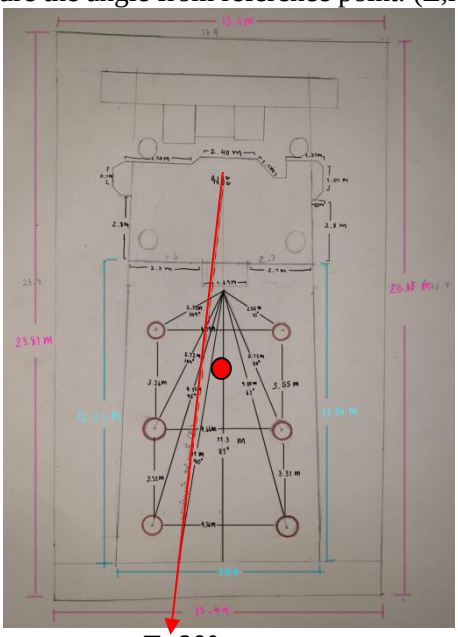
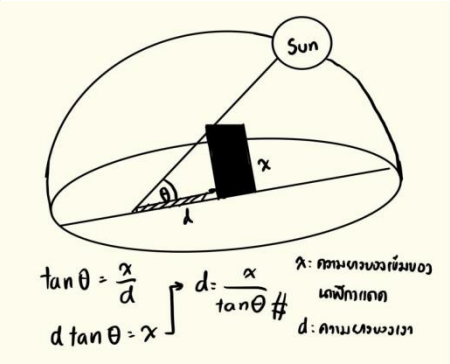
From their works, teachers were classified into STEM education and soft skills such as critical thinking, questioning and problem solving.

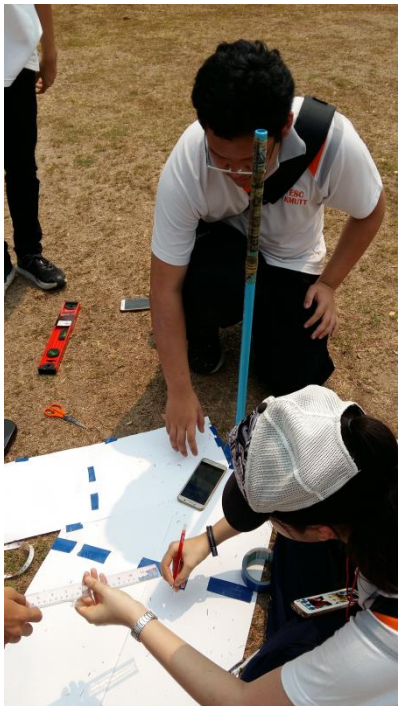
4.2 Results

The results were recorded by teachers after archaeoastronomy activity at Sukhothai field trip and characterized all data into STEM and soft skills using. We found that STEM was used in many steps and mobile apps could help monitoring the celestial phenomena real time. At that time, STEM promoted soft skills using. For example, they used critical thinking to figure out why and how ancient people known about astronomy. First, they observed the sun movement during one day every 30 min and plot graph of the shadow of reference stick. Then, they tried to measure temple and relate the temple angle to vernal equinox (E, 90°). From many evidences, most of students were raising the questions when they

were doing their works. Finally, they were still curious that “Is it possible that ancient Sukhothai people use temple to observe the celestial occurrences?”

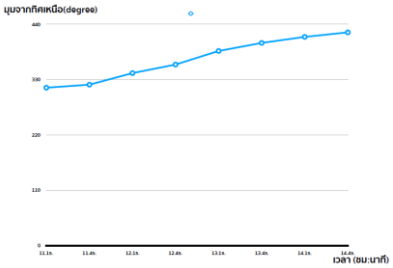
Table 2
The result of students’ works.

Mobile (T)  Wat Mahathat Use compass app and measuring tape to measure the angle of interesting point such as temple door, staircase and temple pillar to reference point (Buddha statue).  **Questioning**: What is archaeoastronomy? Does Sukhothai civilization has archaeoastronomy?	Measure the angle from reference point. (E,M)  **E, 90°** Wat Mahathat The drawing of Wat Mahathat after measuring and scaling and the angle between reference point ( ) and every pillar inside the temple. Students curious that buddha statue may look at ( ).
Mobile (T) Wat Mahathat **Problem solving**: Use mobile sensor to help adjust the problem of tilted floor when they want to study sun position in field.  	Sun position path in 1 day (19 or 20 March 2019) (S, M)  **Critical thinking**: Use similarity of triangles and trigonometry to find out the long of shadow and explore how the sun move during one day at Sukhothai historical park. For the time involved in the length of the shadow, we need to find the position of the sun each day by using the point that the sun intersects with the meridian line as a reference point

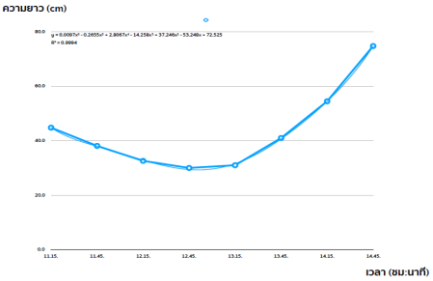


Sun shadow measurement on 19 Mar. 2019 at Wat Mahathat Sukhothai historical park.

Graph showed shadow degree changing during 11.15-14.45.



Graph showed the length of shadow changing during 11.15-14.45.



Presentation

Students presented their works to peers and teachers for sharing the observation using power point presentation.

Discussion

Friends and teachers discussed with presenters for the clearly point of view and criticized some interesting points.

4.3 Limitations

This research had limitations because this work only presents a prototype of the method to see the feasibility and proof of concept. There are still lacking empirical evidences to reveal the effectiveness of the proposed STEM-focused mobile learning approach. It is necessary to receive further studies.

5. Discussion and Conclusion

Ancient study did not divide knowledge but integrated many fields of study when students done the archaeoastronomy activity, they had found many critical points from ancient astronomy. Temple in Thai language is called “Wat” and measure in Thai is also called “Wat” too. Students were very fascinated when teacher introduce that today we were going to “wat the wat” or means we were going to measure (wat) the temple (wat). Why temple was called the same as measure? Many curiosities are rising while we are studying archaeoastronomy. Student’s works were interesting because they can get the point of STEM and present it very good (Table 2). According to STEM-focused and mobile approach, our research discovered that this pedagogy could enhance student’s soft skills such as critical thinking, questioning and problem solving. From teacher observation, student’s behavior showed a

positive intention, good teamwork, raising question and active learning even if the weather was very hot at that day. Finally, they admired Sukhothai people to build the meaningful construction like these.

This is the first time for teacher doing these kinds of activities. Sometime, we cannot reach our plan especially time management was still a big problem. In addition, ancient temple will have only ruined construct while students were studying in the area, it took around two to three hours under the sun without shredding from tree. The weather was so hot because the trip was held on March or summer season so next time we are planning to go to the field on December or winter season to avoid heat stroke condition.

Thailand has its own culture for a longtime. There are so many temples in every province. We believe that archaeoastronomy activity can apply in the others schools of Thailand. But it is not all temples that built based on archaeoastronomy therefore teacher need to find the possible temple and mock up the activity before doing it with students. From this research, it still unclear how can students develop their soft skills during our activity. Thus, further study will focus more about soft skills and measure those skills before and after doing the activity.

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