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Opportunities of Teaching Archaeoastronomy in Thailand

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Abstract

Ancient cultures around the world systematically observed the sky and noticed the motions of celestial objects including the stars, Moon, Sun, and planets. Many structural symbolic patterns were built to perceive, visualize and understand the celestial phenomena. They have used this knowledge, archaeoastronomy, to survive, and as bases for literature, religion, government, and other elements of culture. Understanding the cycles of the celestial objects allowed people to know when to plant, harvest, or move to a different location. This is also the case in Thailand, not only have many ancient stone castles were built in relation with the rise and the set of the Sun in Equinox day but also have few groups of researcher who studied about Thai archaeoastronomy. In addition, Thai people have developed their own knowledge on astronomy for a long time. It has influenced and appeared in many aspects of Thai society such as architecture, literature, philosophical, religious and cultural implications. Nowadays, some countries have been teaching and learning about basic astronomy concepts through archaeoastronomy. Therefore, Thailand should design activities in archaeoastronomy which relatively to the celestial motion content in The 2008 Thai Science Curriculum. This paper will discuss implications of archaeoastronomy and activities in Thailand and other countries. Moreover, it will suggest some effective ideas which Thai teacher can use to improve actions in their astronomy classrooms.

Keywords: Thai archaeoastronomy, archaeoastronomy activities, celestial motion

1. Introduction

Astronomy is probably the oldest science in the world (Osborne, 1991; Jarman & McAleese, 1996; Posayajinda, 2013). Many traditional societies carefully noticed the movement of the Sun, the Moon, stars and planets how to act in the earth. On the basis of these observations, many structural symbolic patterns were built to perceive and understand the sky. For instance, understanding the cycles of the Sun was used to the creation of the solar calendar that importance to agricultural societies (De Pree, Marvel, & Axelrod, 2003) because people needed to know seasons when to plant, harvest, or move to a different location. Recognizing the Moon phases lead to the creation of the lunar calendar which was usually used in Muslim societies and in Buddhist societies. For instance, it used to determine important events which became linked to religion activities e.g, Full Moon days such as the Magha Puja Day (in the 3nd month of the year), Vesaka Puja Day (in the 6th month of the year), and Asalha Puja Day (in the 8th month of the year) in Buddhist societies (Boonyotayan, 2013). Similarly, understanding of the position of the stars could define the direction for journeying at night (Rujopakarn, 2004) thus serving navigational purposes.

Historical astronomers attempted to explain the actual motions of the Sun, Moon and stars from their observations of the apparent motion of celestial objects on Earth (Plummer, 2006). Archaeoastronomy shows how human understanding of the celestial motion (Iwaniszewski, 2006) that may be reflected in the design of the architecture (Iwaniszewski, 2006; Boonyotayan, 2006), Khmer's architecture for example (Sodabanlu, 2010). It was the earliest concept in astronomical knowledge and a decisive factor in the emergence of agriculture and navigation in early civilizations (International Astronomical Union [IAU], 2009).

Archaeoastronomy is multidisciplinary study of archaeology and astronomy (Mollerup, 2007) that is the study of ancient (pre-technological) humankind's awareness of celestial phenomena and its influence on their societies such as how structures were built, early forms of calendars, and the development of mathematical concepts (Peterson, 2000). It is not only deeply rooted in almost every culture (Percy, 2005) but it is still the basis of our modern system of time measurement such as the seasons and the calendar and of navigation and surveying (McNally, 1982). Furthermore, it could be plants a seed of curiosity and eagerness to learn, some countries developed archaeoastronomy activities more interesting and meaningful for teaching and learning in university and in school.

2. Teaching and Learning Archaeoastronomy in the World

In countries that have historical tradition landscapes, it can be employed to help students build on to modern astronomical concept. In places such as United State of America and Europe, teachers can take students to enrich the learning process on archaeoastronomy. These countries have published many research studies from a few of conference on archaeoastronomy. For example, the European society for astronomy in Culture (SEAC) had the 2006 educational workshop in the topic of "teaching and learning archaeoastronomy in USA and Europe and Beyond" (Sims, 2006), and the 2011 Conference on Archaeoastronomy of the American Southwest (CAASW) at the University of New Mexico. These conference occurred for promote standards, education and scholarly interaction on both practice methods and results for the practice of archaeoastronomy.

In addition, they have the archaeoastronomy full course for the graduate level in University of Leicester (Mollerup, 2005) and the University of Wales Trinity Saint David, England (Campion & Malville, 2011). Another archaeoastronomy short course, the archaeoastronomy of the Southwest course, had teaching and learning in the Arizona Archaeological Society, USA. The course is designed to be presented in approximately 34 hours ;20 hours of lecture and 14 hours of outdoor experience. The course content is consisted of three types of archaeoastronomy; alignments of phenomena in the Southwest, light and shadow, and ethnographic data (Bostwick, 2006).

Furthermore, they have the basic archaeoastronomy activities for teaching and learning in school. For example, Burress and Block (2005) created archaeoastronomy units from Chaco Canyon in northwestern New Mexico, for Grade 4-8 USA students. The units consisted of 6 activities; schoolyard medicine wheel, classroom solar calendar, birthday sunbeam, tetherball gnomon, horizon calendar, building a landscape–sun and shadow diorama.

Brown, Neale, and Francis (2010) designed the archaeoastronomy summer school activities for primary students (5-8 years old), at the local Peak District National Park monuments, Britain's first national park. The summer school itself consisted of five days; the first two days, students learning theory, later two days visiting and workshop at ancient monuments and the final day presented the results of their work. The students understand the basic concepts related to shadows using method of the 'Indian circle', an ancient method for determining true east, for a miniature sundial. Moreover, many schools in England ,Germany and Portugal have integrated teaching and learning with the archaeoastronomy activity to promote the student understanding on "light and shadow, and seasonal changes" (Brown & Canas, 2010). In addition, schools in USA, Spain, Australia (Boonyotayan, 2013), Argentina and Brazil (Bekeris & Bonomo, 2011) also design the Eratosthenes method activities for students to measure the circumference of the earth. Eratosthenes, Greek astronomer, lived in Alexandria, Egypt, during the third century B.C. He used the length of the gnomon and its shadow's length, and the distance between two cities where located in the same longitude, to calculate the circumference of the Earth about 2,300 years ago. These activities could be made a good relationship between the first students and teacher team, and another team in the difference school where located in the same longitude and very far from their school (Boonyotayan, 2013).

3. Situation of Archaeoastronomy in Thailand

Asger Mollerup and Sansonthi Boonyotayan were both expert researchers who studied about archaeoastronomy in Thailand. Boonyotayan (2006) studied solar calendar at Prasat (ancient Hindu temple) Phu Phek, Sakonnakhon province and published the content through book and website (www.yclsakhon.com). Mollerup (2007) studied Solar-lunar events at Prasat Phanom Rung, Buriram province, in spring 2007. He also studied about solar event, sundial and calendar at Prasat Phanom Rung, Prasat Phu Phek, and Prasat Sdok Kok Thom (in Thailand), Prasat Preah Vihear (in Cambodia), Prasat Wat phu (in Lao PDR), etc. He also shared his studies through website (www.sundial.thai-isan-lao.com). In addition, The National Astronomical Research Institute of Thailand (NARIT) also showing to interest in archaeoastronomy through "The first sun shine ray of the day passed through the 15 doorways of the Phanom Rung sanctuary" camp in 2010 and in 2014 they published the Thai astronomy civilization book series; Thai archaeoastronomy, Thai Royal astronomy, and Thai indigenous astronomy.

The research study on archaeoastronomy and its activities in Thailand were interested for small groups and it usually used only to promote tourisms such as on April 3-5 and September 8-10, every year promoting the sun shine ray passed through 15 doorways of the Prasat Phanom Rung, and proving the solar calendar at Prasat Phu

Phek on the Equinox days. However, some organizations attempt to create some archaeoastronomy activities for student. For example, the Learning centre for Earth Science and Astronomy (LESA) created the 1st science and cultural activity for the next generation Khmer-Thai project on October 3, 2003 and second time on March 11, 2009. The activity designed to examine that the Prasat Phanom Rung at the beginning time (944-968; King Rachentaraworaman III) was located facing the sunrise at the first point of Aries zodiac (Boonyothayan, 2013). Anantasook (2011) also studied about the main direction structure of 30 prasats in Surin province, Thailand, and found that some of them were Equinocial temple as the solar calendar and then designed the poster as learning material and activities form this local wisdom on astronomy for students. They could be used Prasat direction and detail information on the poster to specify the age of the building.

In addition, the National Science Museum (NSM) also training teachers on Eratosthenes method for measure the circumference of the Earth that is started since 2008. Although some attended teachers brought this activity to their class such as teacher in Sri Buabarn Wittayakom school, Nakornpanom province, and Ampawan Wittaya school, Ubon Ratchathani province (Boonyotayan, 2013), there is no evidence showing that the activity was use effectively in class. Therefore, Thai archaeoastronomy lesson activity should was designed which depending on Thai societal and cultural contexts, and relatively to astronomy and space contents in the 2008 Thai science curriculum. Then, investigates the effectiveness of archaeoastronomy instructional designed to help students learn astronomical concepts.

4. Archaeoastronomy in Thai Context

Astronomy has been embedded in Thai society for a long time. Long before telescopes, Thai ancient people observed sunrises and sunsets, the moon phases, and the motion of the stars by their naked-eyes. In the Khmer era (557-1431), the Khmer who were ancient Cambodian, were in power in Thai regions. They knew well the cycles of the Sun and even then could determine the Equinox day (the day when the Sun rises in true east and set in true west) as evidenced by the stone inscription in the Prasat Sra-khumpang Yai in Sisaket province, Thailand. This inscription mentions activities on the Vernal Equinox day in the year 1042 (Boonyotayan, 2006). In addition, many other Prasat were built in positions relative to the rising and setting of the Sun on the Equinox day and the main Prasat structures were placed either in the north, south, east or west (Anantasook, 2011). These ancient astronomical ideas influenced architectural design in important places such as palaces, towns, pagodas, chapels and modern building from the past to the present (Patwong, 2012).

In the Sukhothai era (1249-1438), people used the Saka calendar, a form of solar calendar, which had the first day of the year on the Vernal Equinox day, i.e., was March 21st or March 22nd (Boonyothayan, 2013), and used a lunar calendar for royal historical annals and for Buddhist activities. In the Sukhothai stone inscription (1279-1298) the directions north (Plai Tenn; tiptoe) and south (Hua Non; head of the bed) can be found. These words are still used by some modern Thais to this day. Pluluang (1996) informs us that the ancient people always looked for and used the Northern star, Polaris, as a direction marker. Thus when emergencies occurred in navigation, they turned their heads toward the south to look for Polaris on the nights, and used this information to get their bearings so they knew where to go especially to safety.

In the Ayutthaya era (1350-1767), Thai people continued to use the Saka calendar and the lunar calendar for the same purposes and people watched the sky using traditional methods. However, the King Narai (1656-1688) had a telescope to observe the celestial motion (Vinichai, 1988).

In the first period of the Rattanakosin era (1782-1851), Thai knowledge about observing the stars was located in the "Tumradao" which are Thai astronomical texts. Many of the Tumradao tell about how to read the stars, clouds, the sky, eclipses, comets, the moon and other astronomical phenomena for understanding predicting the effect of astronomical events on everyday lives. In addition, Thais use the position, and the rise and the setting of specific stars to tell of any auspicious times, or the fate of towns and individuals (Pengkaew, 2000). Furthermore, the occurrence of Thais reading stars has also appeared in Thai novels such as "E-nau" and "Pra-Apaimanee". Some novels talk about zodiacal constellations giving them Thai names such as daolong (coffin star), daotai (plow stars), daowow (kite stars), daotao (turtle stars), and daogorrake (crocodile stars) (Saiphet, 2012).

In the reign of King Rama IV (1851-1868), the King was particularly interested in astronomy. He used the archaeoastronomy technique to determine true direction of once location and set a Siam clock tower in his palace at 100 degrees East longitude in order to establish Bangkok Mean Time in 1852. This achievement was earlier than Greenwich Mean Time which was set in 1880 (Vinichai, 1988). He also appointed two positions officers for precise time keeping of the Siam clock - the first science work in Thailand. The first position was Pan Tiwathit (the sun officer) who observed and defined daytime from the Sun and the other was Pan Pinitchandra (the moon officer) who observed and defined nighttime from the Moon (Muanwong, 1988).

From above Thai historical information, the astronomical knowledge plays an important role in Thais lifestyle, belief, religious, culture, intellectual and architecture. Thai people learned and knew about the relationship between the apparent celestial motion and the passage of time when to plant and celebrate special days which have been set for Buddhism activities (Boonyotayan, 2013). Then, archaeoastronomy could be useful as live-classroom and research for inspire students in the basic educational level to interesting and understanding in celestial motion concepts.

5. Archaeoastronomy Could Be Set in Thai Science Curriculum

Celestial motion is the term used for the motion of celestial objects such as the Sun, Moon, stars and planets (IAU, 2009) and such concepts are embedded in the Thai Science curriculum. Astronomical concepts related to celestial motion are included in Standard Sc 7.1 of the Science learning area in the 2008 Science curriculum (The Institute for Promotion of Teaching Science and Technology [IPST], 2018) which was described in the following:

Standard Sc 7.1: The student should be able to understand the evolution of the solar system, and galaxies, interactions within the solar system, their effects on living things on Earth, practice investigative process skills and develop a scientific mind, communicate the acquired knowledge and make use of it.

Celestial motion concepts feature as key components of the astronomy and space performance indicators, particularly at the primary and lower secondary levels. Table 1 illustrates the astronomy and space performance indicators for students at the primary and lower secondary level particularly for standards Sc 7.1.

Table 1. A Summary of astronomy indicators in the primary and lower secondary level

Grade level	Indicators
Grade 1	Indicate that there are the Sun, the Moon and the Stars in the sky.
Grade 2	Search for and discuss the importance of the Sun.
Grade 3	Observe and explain the rising and setting of the Sun and the Moon, the causes of days and nights, and determine direction.
Grade 4	Construct a model to explain the characteristics of the Solar System.
Grade 5	Observe and explain determination of direction, as well as the rising and falling phenomena of stars, by using a star chart.
Grade 6	Construct a model and explain the cause of seasons, phases of the Moon, solar and a lunar eclipse, and apply this knowledge.
Grade 9	1. Search for information to explain relationships between the Sun, the Earth, the Moon and other planets, and their effects on the environment and living things on Earth.
	2. Search for information to explain the components of the universe, galaxies and the Solar system.
	3. Identify positions of constellations, and apply this knowledge.

According to Table 1, At the primary level (Grade1-6), celestial motion concepts are concerned with those astronomical phenomena that can be found in daily life such as : the appearance of the Sun, Moon, and the stars in the sky (day and night); directions on the Earth; the movement of the stars; Moon phases; the seasons; and solar and lunar eclipses. Each concept is taught separately at each primary grade level and once students finish primary schooling there is a two year gap before they learn celestial motion concepts again at secondary school. At the lower secondary level (Grade 9), celestial motion concepts are concerned with the relationships between the Sun, the Earth, the Moon, constellations and other planets, and their effects on the environment and living things on Earth (IPST, 2011).

Because of archaeoastronomy concern with the human understanding of the celestial motion (Iwaniszewski, 2006) and celestial phenomena (Peterson, 2000), teaching and learning on celestial motion concept in Thai classrooms could be use archaeoastronomy activities which appropriate for each level.

6. Examples of Teaching Archaeoastronomy in Thailand

According to Standard Sc 7.1 indicators and the archaeoastronomy in Thai context, classroom activities on archaeoastronomy should include more practical and experimentation as follow;

1) Gnomon and shadow plot was used by ancient people to find true north, south, east and west in structuring the important buildings that related to the sunrise in the special day such as Khmer who built the Angkor Wat (The largest religion monument in Cambodia was built in 1113-1150; King Suriyaworaman II) facing to the position of sunrise in Vernal Equinox day (Boonyothayan, 2013). Student should be using gnomon and shadow plot to identify true north, south, east and west in school or in each student's house, then create the sundial and find the north celestial pole, Polaris, and observe night sky.

2) Sundials both equatorial sundial and horizontal sundial were fundamental instruments to tell the solar day time since in the history until now when human without the modern clock (Boonyothayan, 2013). It was built base on the relation between the latitude on earth and the sun pathway. However, the horizontal sundial is more appropriate in countries with high latitudes, not for Thailand that is close to the equator. The equatorial sundial consisted of a gnomon and dial plate; the gnomon should be parallel to the Earth's axis that inclined at an angle equal the latitude of the observer while the dial plate should be parallel to the plane of the Earth's equator and perpendicular to the gnomon (LESA project, 2003). Students should be making different kind of sundial matching to their latitude and society.

3) The inclination of the Earth's rotation axis causes the seasons. The duration of the day to change during the year, and as a consequence the sunrise and sunset points change throughout the year. For observers on the Earth, understanding the cycles of the Sun was used to the creation of the solar calendar (De Pree, Marvel, & Axelrod, 2003), placed the main sanctuary structures relative to the rising and setting of the Sun in the important days such as Vernal Equinox, Summer Solstice, Autumnal Equinox and Winter Solstice (Anantasook, 2011; Patwong, 2012). Students should be applied these ideas for creation of the solar calendar that related to their communities, and designing of the important place or residence were related to the sun movement which affecting the suitable light passing through the buildings.

4) The moon rises around 50 minutes later each day than the previous day. The shape varies from a full moon (when the Earth is between the sun and the moon) to a new moon (when the moon is between the sun and the Earth). Lunar calendar is a calendar that is base on the patterns of Moon phases. It is the purely Islamic calendar in Muslim societies, and also used to identify the *Wanpra* (holy day in first quarter, full moon, last quarter, and new moon) in Buddhist societies (Boonyotayan, 2013). Students should be participation and observations the cycle of moon phases (Plummer, 2006), taking a collection of moon image and create by themselves, the lunar calendar which related to their cultural activities.

5) The human eye can see about 6,000 stars without aid and were grouped into constellations. At various times of year, different constellations appear at sunset that ancient human use to mark the season (IAU, 2009), the direction for journeying at night (Pluluang, 1996; Rujopakarn, 2004), and prediction human life as the astrology (Pengkaew, 2000). Although it is not necessary for today technological world, the philosopher in the ancient time usually observed the night sky with naked-eye, imagination, and attempts to answers the astronomical hypothesis (Posayajinda, 2013). Observing stars are not only relaxation but also motivate observer to construct some significant knowledge for their communities (Pengkaew, 2000). Students requires direct experience for watching stars in the real sky and compare with the night sky in the electronic program, and specify the position of zodiac and constellations with both Thai and international names. Then, create the Thai star mapping which recorded the position of the planets at the zodiac spherical at the interested time such as the time when constructed the importance building.

7. Conclusion

Nowadays, astronomy becomes more popular in Thailand. People enjoy participating in many astronomical activities and learning more about it, and astronomy has become an important tool for promoting science awareness and alertness (Soonthornthum, 2009). Astronomy and Space content are put systematically in Thai science curriculum in both the 2001 Basic National Education and the 2008 Basic Education Core Curriculum (Ministry of Education, Thailand, 2008).

The Institute for the Promotion of Teaching Science and Technology (IPST) is responsible for developing the curriculum, and teaching Medias. IPST is also responsible for teacher's development since 2003, for their understanding in classroom activities in according to astronomy standards and indicators. In addition, others organizations such as Thai astronomy society, the Learning centre for Earth Science and Astronomy (LESA), and the National Astronomical Research Institute of Thailand (NARIT) also training astronomy teachers annually.

It can mention that now is important time to develop astronomy study in Thailand. Teachers interested and pay more attention in developing classroom activities, learning media or academic project on astronomy. Archaeoastronomy is the alternative choice for teaching and learning because it not only fascinating and embedded in Thai historical culture and societies, but also relevance to celestial motion concepts in the astronomy and space strands on science curriculum. Hence, it is important to encourage teachers to develop classroom activities, media, and teachers themselves about pedagogy content knowledge (PCK) on archaeoastronomy. This might increase teachers' confident, and make more exciting astronomy teaching and learning. In addition, students could be motivated easily to learn astronomy concept because that is related to their culture and daily life as it is meaningful and useful in their lives.

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