Applying Social Media for Measure Earth's Circumference from Different Locations on the Vernal Equinox

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Abstract: The calculation of the Earth's circumference using Eratosthenes' method requires that; (1) the vertical angle of the sun at solar noon between two locations along the same line of longitude, and (2) the distance between the two locations. The Earth's circumference measurement on 2014 Vernal Equinox operated with the same method and difference technique. On the Vernal Equinox the Sun move on the Equator, the vertical angle and distance between two locations could be referred with the Equator. The naïve participants (N=67) from different locations (Thailand, Lao, and New Zealand) successes the measurement through the social media which was applied to support this project. The results reveal that the online network highly supported teachers and students to complete the activity. They only learning the content from the weblog, 82.32% of them intensively understand the activity and using the Google earth program for measure the distance between their locations to equator. The scientific results have 0.02-12.50 % error which less than the Eratosthenes error (15.60%). It also indicated that social media could be used to create a collaborative network for science laboratory and developing astronomy teaching and learning in both Thailand and ASEAN country.

Keywords: Earth's Circumference, Eratosthenes Method, Social Media

1. Introduction

Eratosthenes (276 - 197 B.C.) was a Greek mathematician, astronomer, geographer, poet, and even a music theorist, who live in Alexandria, Egypt. He is credited with the first remarkably accurate measurement of Earth's circumference in about 2,300 years ago.

Eratosthenes knew that on the summer solstice (on June 21), at noon, in Syene (now Aswan, Egypt, 23.5° north latitude), a city located south of Alexandria, gnomon and pillars cast no shadow. This observation meant that the Sun was directly over the city of Syene, as shown in Figure 1. However, the same thing was not happening in his home town, Alexandria. He saw that a gnomon planted in the ground cast a shadow measuring 7.2 degrees. (See Figure 1.)

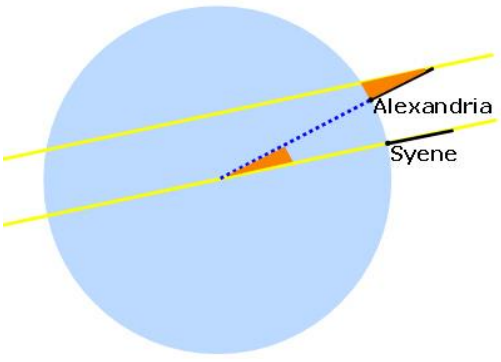

Figure 1. Syene and Alexandria are separated by an angle of 7.2 degrees
(Resource: http://www.sciencebuddies.org/Files/2677/3/Astro_img061.jpg)

In Figure 1., If extend the gnomons until they meet at the center of the Earth. Since the sun's rays are parallel and that alternate angles are equal, it can mention that Syene and Alexandria are separated by an angle of 7.2 degrees.

Eratosthenes paid the team to pace out the distance between Syene and Alexandria, and he found to be 5,000 stadia (the stadia is an ancient unit of length equal to about 1/10 of a mile). Then, using proportion he found the circumference from the following equation:

$$\frac{Circumference}{5{,}000 stadia} = \frac{360^o}{7.2^o} \qquad \ldots (1)$$

He calculated the circumference of Earth and found it to be 250,000 stadia or about 25,000 miles. If Eratosthenes used the present Egyptian stadia of about 185 meters, his measurement turns out to be 46,250 km, an error at 15.60% to today's numbers. The circumference of the Earth between the North and South Pole is 40,008 km (Boonyotayan, 2013).

Eratosthenes' method requires known that; (1) the vertical angle of the sun above the horizon or from the zenith (a point directly overhead) at solar noon (solar noon is the time at the sun reaches its highest point in the sky and is closest to being directly overhead) at two locations along the same line of longitude and (2) the distance between the two locations.

Since the World Year of Physics 2005, Eratosthenes' method was used to promote science in high schools. Particularly, in the International Year of Astronomy (2009), on the summer solstice, the Argentinean project Eratosthenes 2009 on June 21st, and Eratosthenes America 2010 between 18 and 24 June, have more than 15,000 students at more than 200 schools each year used a web network for learning content and found the partner determined the Earth's circumference. Groups of students at two distant schools and the same longitude will take data and then communicate and collaborate on the same way that Eratosthenes measured the circumference of the Earth (Bekeris at al., 2011).

In Thailand, the National Science Museum (NSM) also training teachers on Eratosthenes' method for measure the circumference of the Earth that is started since 2008. Some attended teachers brought this activity to successfully calculated with pair secondary schools such as Eratosthenes projects on 2010 Winter solstice (December, 21st) between Sri Buabarn Wittayakom school, Nakornpanom province, and Ampawan Wittaya school, Ubon Ratchathani province (Boonyotayan, 2013). However, workshop in each school was used for understanding Eratosthenes' method and using the telephone for communicate throughout the activity.

The author, while he stayed in University of Waikato, New Zealand thought that the Earth's circumference measurement using Eratosthenes' method could be operate on the Equinox day (21 March or 23 September). Because of the Sun move on the Equator in these days, the vertical angle of the sun at solar noon and the distance between two locations could compare with Equator.

The author also used the Eratosthenes' method, and add a difference technique for measure Earth's circumference. He suggested the Google Earth free online program for measured the distance from the participants' location to the Equator and applied social media to support the Earth's circumference measurement on 2014 Vernal Equinox (21 March) from different location (Thailand, Lao PDR, and New Zealand) (Anantasook and Yuenyong, 2014).

Social media is a 21st century term used to broadly define a variety of networked tools or technologies that emphasize the social aspects of the internet as a channel for communication, collaboration, and creative expression, and is often interchangeable with the terms Web 2.0 and social software (Dabbagh & Reo, 2011). The different types of social media were used in this measurement included the blog, facebook, and google docs.

A weblog (blog) is a web-based technology that allows people to quickly share their thoughts and comments with the entire web population (Huang, 2011). The author created many articles about the Eratosthenes' method, and step of using the Google Earth program on the astronomy education's blog (www.astroeducation.com). The participants will learn the content and follow the authors' idea and Eratosthenes' steps from the blog.

Facebook is a popular free social networking website that allows registered users to create profiles, up load photos and video, send messages and keep in touch with friends, family and colleagues (Kabkhum, 2010). The author invited teachers who need attended in the measurement on his facebook address (www.facebook.com/krusmart) and add participants' address in the "Wisuwat Earth's Size" facebook's group. He used this online group to directly contact them, shared the content from the blog, assigned work, uploads the participants' activity pictures, and reported the results of the measurement.

Google Docs is a word processor program, a free web-based software office suite offered by Google. The users could be created, edited documents online while collaborating with other users in an internet connection. It had the form of questionnaire and the program could connect and show on the weblog (Anantasook, 2014). It was used for participants immediately reported the results and comment their opinions after they finished the measurement.

2. The purpose of the study

2.1 Applying social media for measured the circumferences of the Earth on the 2014 Vernal Equinox.

2.2 Evaluated activities used by participants in term of the result of the measurement, and their opinions.

3. Methodology

Participants

The project involved 18 teams (N=67); the author from New Zealand, team of 3 students from Pakse teacher collage, Lao PDR., and Thailand teams that includes the team of 4 students from Rajabhat Surin university and 15 teams from different both location and education level (8 teachers and 19 students from the primary school, 13 teachers and 19 students from the secondary school).

Idea of instrument; Eratosthenes' measurement on the Vernal Equinox

The measurements were made between 20 and 21 March 2014 (as shown in Figure. 3-10). On the Vernal Equinox day the Sun move on the Equator, so at noon, the sun was directly overhead, the gnomon cast no shadow while in others latitude a gnomon planted in the ground cast a shadow (as shown in Figure 2.).

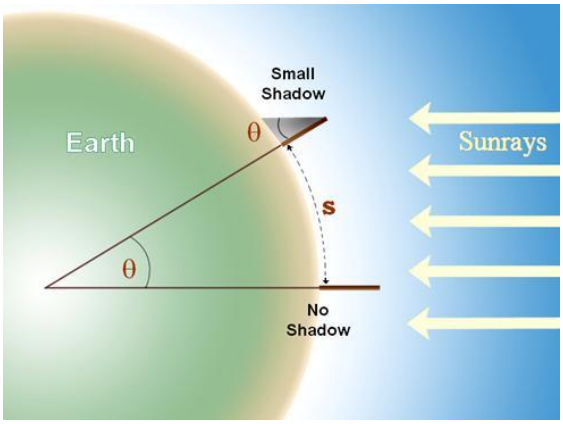

Figure 2. Relationship between the direction of Sun's ray, the gnomon and the vertical angle (Resource: http://www.iucaa.ernet.in/~scipop/Obsetion/eratos/image008)

In Figure 2., if we know the height of the gnomon and the length of the shadow, the vertical angle of the sun between two locations along the same line of longitude (or difference between their latitude) (θ) could be found which using the following equation:

$$\tan\theta = \frac{length\ \ of\ \ the\ \ shadow}{height\ \ of\ \ the\ \ gnomon} \qquad \ldots (2)$$

In addition, the distance between location from the equator to the school's locations at the same longitude (s) in this projects have two ways for participants selected; one using the Google earth program and another was compare and calculate from scale on the book map.

Then, the Earth's circumference could be found from this following equation:

$$\frac{Earth's\ circumference}{DisTance\ between\ \ location} = \frac{360^{O}}{difference\ \ in\ \ lattitude} \qquad \ldots (3)$$

Data Collection and Analysis

1. Design integrated and participatory learning activities for measured the Earth's circumferences on the 2014 Vernal Equinox using mathematics, astronomy, and information technology (the Google Earth program).

2. Applying social media that included the blog, facebook, and google docs on the astronomy education's blog (www.astroeducation.com) supported the Earth's circumferences measurement.

3. Invite author's friends page who interested to join in the project through his facebook, add participants' address in the facebook's group (Facebook/groups/372550369554908/), and use it for any communication throughout the measurement.

4. The participants learn the lesson of Vernal Equinox Eratosthenes' measurement from the blog three days before starting the project.

5. The Vernal Equinox Eratosthenes' measurement included 2 days activities. In the first day, 20 March, all participants using gnomon and shadow plot (during 11 a.m.-1 p.m.) to identify true north, south, east and west in their location. Then, on the vernal Equinox day, 21 March, they also using the same both gnomon and location to measure the length of shadow at solar noon time which the shadow must cast to the true north for the Northern countries or cast to the true south for the Southern countries. Finally, they could be measure the distance between their locations to equator base on their decision and using equation (3) for calculated the Earth's circumference.

6. The participants reported the results of the measurement and gave their opinions about the activity through the facebook's group and Google Docs questionnaire online.

7. The result of the measurement and participants' opinions were analyzed and described.

4. Finding and Discussion

4.1 The scientific results of the Earth's circumference measurement.

The results of the Earth's circumference measurement on the 2014 Vernal Equinox from different geographic locations (20-21 March), as shown in Table 1.

Table 1. The results of the Earth's circumference measurement on the 2014 Vernal Equinox

Team	Geographic locations Longitude, Lattitude	Height of gnomon (cm)	Length of shadow (cm)	tan θ	θ (degree)	Distance between location (km)	Earth's circumference (km)	Error (%)
NZ	37:47S, 175:19E	3.8	3.2	0.842	40.1	4,183.72	37,559.58	6.12
Lao	15:07N, 105.49E	7	2.1	0.300	16.7	1671.96	36,042.25	9.91
1	14:51N, 103.29E	4.6	1.4	0.304	16.9	1643.33	35,005.84	12.50
2	17:30N, 104.40E	4.4	1.1	0.250	14	1892.08	48,652.94	21.61
	16:06N, 104.14E	8.6	2.3	0.267	15	1780.49	42,731.76	6.80
3	15:41N, 100.07E	54	15	0.277	15.52	1736	40,268	0.65
4	15:41N, 101.45E	7	2	0.285	15.50	1717	39,878.71	0.32
5	15:41N, 101.45E	7.2	2	0.278	15.52	1717	39,827.32	0.45
6	8.2N, 100.02E	21.5	3.3	0.153	8.7	911.27	37,707.56	5.74
7	15:41N, 100.07E	15	4.5	0.300	16.7	1736	37,445	6.40
8	15:59N, 103.29E	10.5	3.10	0.295	16.4	1771.97	38,885.05	2.80
9	15:59N, 103.29E	13	3.5	0.269	15.06	1771.97	42,357.84	4.69
10	16:3N, 99:51E	13.30	3.70	0.278	15	1777.14	42,651.36	6.60
11	16:30N, 103:30E	3.6	1.2	0.472	18.43	1846.61	36,060.78	9.86
12	102:46N,17:10E	60	18.4	0.307	17	1888.94	40,001.08	0.02
13	15:41N, 101.45E	14	3.5	0.250	14.5	1717	42,628.96	6.55
14	15:41N, 101.45E	15.8	5	0.316	17.5	1717	35,321.14	11.72
15	14:56N, 102.19E	5	1	0.200	11.31	1250	39,791.31	0.54
16	14:56N, 102.19E	10	2	0.200	11.31	1250	39,791.31	0.54

Note ; Team 6, 15, and 16 measured the distance from the equator to the school's locations using scale comparing on the book map while others using the Google earth program.

According to Table 1, the participants from different geographic locations successes the Earth's circumference measurement through the social media. The scientific results have 0.02-12.50 % error which less than the Eratosthenes error (15.60%). It could be firmly that the Earth's circumference measurement could operate on the Vernal Equinox with in the author's assumption. In addition, the social media which created for this activity very useful and effective online network because it highly supported teachers and students to completed the measurements. All of them never know about Eratosthenes method before attended in the project but they could be calculated the Earth's circumference between the North and South Pole nearly present number (40,008 km).

4.2 Participants' Opinions after attend in the Earth's circumference measurement

After students did the Earth's circumference measurement on the 2014 Vernal Equinox, some like the project the most since the following opinions:

Although the weather so hot, It was fun.

I learned something that I didn't know.

It let me know about the easy method to know the earths' size.
We and teachers did the experiment themselves together.
I first time used the Google earth program, I saw my house from the space.

Some teachers also liked this activity the most and evaluated the effect to students after attend in the measurement since the following opinions:

It was interesting activity. I would apply for my teaching.
It is the way to make students fun, participatory and exciting at all steps.
It lets students take the action, get knowledge and be fun.
It is good for practicing observation and experiment.
I got the ideas of applying social media for teaching and learning.
We are astronomy educator online network.

According to participant's responds, the author consider that they have more technological skill such as the following reasons;

1. All participants know the Earth's circumference measurement on 2014 Vernal Equinox from the author's facebook and they submit to this activity through the facebook.

2. Each facebook participants addresses were added to the "Wisuwat Earth's Size Group". They usually communicated, collaborated, contacted, asked the problem, and reported the result through this channel. The members sometime give some ideas for solve the problem, and also received spirit from many friends on the group.

3. They were only learning the content from the weblog, 82.32% of them intensively understand all steps before the measurement.

4. They first time downloads, setting and using the Google earth program, 82.32% of teams selected it for measure the distance between their locations to equator, while others (17.68%) using scale comparing and calculating from the book map.

In addition, all teachers could be a good advisor for supported students to complete the scientific projects. They showed more competencies on using the social media for astronomy activity. They got the ideas of applying social media for teaching and learning such as create the blog's content and used it in their classrooms.

5. Conclusion and Suggestion

The naïve participants from different locations completed the measurement through the social media. The results reveal that the online network highly supported teachers and students to success the activity. They only learning the content from the weblog, 82.32% of them intensively understand the activity and using the Google earth program for measure the distance between their locations to equator. The scientific results have 0.02-12.50 % error which less than the Eratosthenes error (15.60%). This measurement technics could be used useful and effective in every the Vernal Equinox and also in the Autumn Equinox (23 September). It was suitable for all student level but it was the best for secondary students.

Furthermore, the worksheet of "The Earth's circumference measurement on the 2014 Vernal Equinox" was translated from Thai version to Lao language and it was used in the student team from Pakse teacher collage measurement. The astronomy education blog could build astronomy teachers' community up. Again, the weblog provided more interaction between experts and naïve astronomy teachers. It build atmosphere of professional development through the blog (Anantasook and Yuenyong, 2014). The blog also give naïve participants more chance to argue for developing their scientific conclusion (Pimvichai and Yuenyong, 2014). This situation can mention that social media could be used to create a collaborative

network for developing astronomy teaching and learning not only in Thailand but also effective at the international level, in ASEAN community.

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Appendix: Some of the participants' measurement on the 2014 Vernal Equinox

Figure 3. The author at the Waikato Uni., NZ

Figure 4. Students from Pakse, Lao PDR.

Figure 5. Students from Rajabhat Surin university

Figure 6. Team 6 Tangpoon wittayakan school

Figure 7. Team 7 Satree Nakhonsawan Schools

Figure 8. Team 10 Sahatsakhan Suksa Schools

Figure 9. Team 11 Nongsang Wittaya Suksa Schools

Figure 10. Team 13 Jaturat Wittaya Schools