How to Apply Technology in STEM Education Activities

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Abstract. STEM has been playing a part in Thailand for quite some time. STEM teaching and learning is originated from the US. Later, many countries have applied it to their own education systems. Since the arrival of STEM, ministry of education, under the supervision of teaching science and technology by Institute for the Promotion of Teaching Science and Technology, has used this teaching model. National Legislative Assembly of Thailand has also proposed STEM policy in order to gain tangible results. Until now, there is still no clarity and there are confusions with the organization of STEM teaching and learning. This article aims to propose the idea of the application technology in project-based STEM Activities. The content of this article contains concept of STEM, meaning of STEM, policy and principle of STEM for development of the nation, environment of STEM teaching and learning, and case study of applying technology with project-based STEM activities.

Keywords: How to Apply Technology, STEM Education

1. Introduction

Concept of STEM

Apisith Thongchai and et al (2012) concluded that STEM is an acronym for Science, Technology, Engineering and Mathematics. The concept of STEM is originated in the US from the gathering of the representatives from every prominent sectors in the country with the aim to improve the quality of the population by enhancing their skills in order to be able to compete with other nations. The government had the education policy to support learning and teaching by integrate these four subjects together. Up to now the word STEM is popularized as the government wished to promote this kind of teaching and learning. Nevertheless, there was still quite many misunderstandings toward STEM. Many people were more familiar with Science and Mathematics. General Education also concentrated on these two subjects. Moreover, many also misunderstood STEM as an invention or development of a way of learning that promote each individual subject. In fact, STEM is an integration of four subjects, namely Science, Technology, Engineering and Mathematics, which each of the subject holds the same importance. STEM engages learners to use all subjects to solve the problems, research and create or develop things in the present. The teaching is formed by teachers which come from many areas of expertise. In the real working world, knowledge from many areas needs to be combined and not separate into parts. This supports the essential skills of development in globalization. However, from the past to present, each subject is still being taught independently. [1]
Rakpol Thananuwong (2013) wrote that STEM Education is learning of content and the skills of Science, Mathematics, Engineering and Technology. These four cores are the subjects which promote learners to gain knowledge and has a quality living in the 21st century, a fast-pace, globalized and full of technology era. The four subjects are essential to enhance the capabilities of economic competition, the development of the life quality and the nation’s security.

In the past, the learning of these four subjects in STEM are separated and independent, for example STEM teaching and learning in Thailand or in the US had courses of Science, Mathematics, Engineering and Technology separately with the lesser focus on the engineering. Educators and academics in the US have compared this separation of the four subjects as “silo”, which lies independently in the field.[2]

It was found that at present the US was not the first when measuring nation’s capacity like it used to be in the past. Many countries around the world have made progresses. The PISA results also showed that the US was worse than many countries. Moreover, the population of science, technology and engineering also dwindled. Thus, the government has implemented a policy which supports the development of STEM. They hoped to raise the PISA results. Furthermore, the swift changes of technology, especially in the communication, logistics, trading, etc, makes the world globalized so it is utmost importance to bring STEM teaching and learning to support the necessary skills in the 21st century. (Apisith Thongchai, et al 2012) [1]

Pornthip Siripatrachai (2013) said the necessary skills for the 21st century began from the assembly of academics from many expertises in the US. The government wanted to improve to quality of the people in order to elevate the capacity of the nation so it can compete with others. They also wanted their people to has quality and ability in the society so that they can live in the swiftly changing world. Thus, equipping learners with the 21st Century Student Outcomes, which contains knowledge, skills and expertise is essential. (The Partnership for 21st Century Skills, 2009). The outcomes are as follows, [3]

![Figure 1](http://www.p21.org/about-us/p21-framework)

**Figure 1. The Partnership for 21st Century Skills (2009)**

1. Core Subjects and 21st Century Themes are English, Reading, Art of language using, foreign languages, mathematics, economics, science. Art, Geography, History, Citizenship, Political Science. These subjects also need to cover the new areas of content which will influence work and community. Education institutes also have not given enough importance toward subjects such as awareness toward the earth, fundamental course of finance, economics, administration, entrepreneurship, civil and awareness for health and welfare.
2. Learning and Innovation Skills, as follows
   - Creativity and Innovation which covers creative design, collaborate creatively with others and application of creativity.
   - Critical Thinking and Problem Solving which includes rational thinking, systematical thinking, decision making and solving problems.
   - Communication and Collaboration which concentrates on communication by using various types of media and collaboration with others effectively and clearly.

3. Information, Media and Technology Skills. In the 21st century, which many technological advancements, learners need to know the these following skills.
   - Information Literacy
   - Media Literacy
   - ICT (Information, Communications & Technology) Literacy

4. Life and Career Skills. In our daily and working lives, we need not only the people who have knowledge and thinking skills, but we also need the people who are able to work in a complex context. These necessary skills are as follows.
   - Flexibility and Adaptability
   - Initiative and Self Direction
   - Social and Cross-cultural Skills
   - Productivity and Accountability
   - Leadership and Responsibility

2. STEM: Meaning and its importance

   Originated from the US, the concept and principle of STEM was announced to be its national policy. After that many countries received and adapted STEM to their own nations. Especially in Thailand, STEM has been applied to teaching and learning of Science and Technology. There are many definitions to STEM such as

   STEM is a way of organizing education that integrate four subjects, which are Science, Engineering, Technology and Mathematics. STEM concentrates on practicality of the knowledge to be used in real life, including the development of processes or products, which benefit the working and living. [4]

   Wasinee Itsarasena Na Ayutthaya(2017) gave definition to STEM as a way of organizing education that is influencing the changes of human in the 21st century. STEM Education or STEM is derived from the integration of four subjects as S stands for Science, T for Technology, E for Engineering and M for Mathematics. STEM also means root, which can imply to the foundation that causes development and changes to human. These four subjects are necessary skills to human of the present and the future. The teaching of STEM is different from the past that required learners to recite. STEM Education is an integration of Science, Technology, Engineering and Mathematics which allows learners to experience, practice, and think creatively of how to solve the problems. STEM Education should be taught from kindergarten level as it trains learners to be curious for new knowledge and know to solve problems. Consequently, they grow up having a systematic thinking and they are aware of the changes and the advancement of technology in the world. Teaching STEM to learners from their young age will also create good attitude toward Science and Mathematics, which often seen from the learners as difficult subjects and being dislike. In the long term, this could influence the young generation to be interested in Sciences, Technology, Engineering and Mathematics. Consequently, more people will be working in the areas of Science-Mathematics which allows the number to be met with the needs in economic and technological markets at present and in the future. STEM Education is therefore very important for human development. Teaching and learning STEM with other subjects such as language, arts, social science and morality will create holistic knowledge and skills for people in order to improve the quality of our society.[5]
3. Policy of STEM education

The policy proposal of STEM education which aims at integrating knowledge of science, technology, engineering and mathematics emphasizing on problem solving in real life to promote additional experiences, life skills and creativities as well as to prepare the students to be ready for any practices that require scientific, technological and mathematical knowledge and process that lead to future innovation. It is an enjoyable learning and teaching process for students and benefits their future careers. STEM education helps establish manpower who has skills on problem solving, creativity and new creative innovation. Hence, it is the important foundation of innovative skill development and the significant mechanism in improving economy of Thailand to higher income level in the future and being able to integrate knowledge from real life and working. Social stimulation of STEM educational significance would cause developmental mechanism for scientific, technological and innovative manpower for society. Public hearing of organizations, institutes and associations, especially those who use the products of STEM education, plays a role in developing manpower and pushing forward national policy to support Thailand’s innovative systems. [6]

4. Organizing STEM teaching and learning

Apisit Thongchai et al (2012) elaborated the above mentioned of the necessary skills for the 21st century and the nature of the its science as follows,

- Science is a study of natural phenomena by using the process of Scientific Inquiry. Science is tools that make human understand more about nature. In May 2012, the US promoted the new Science K-12 Framework and published for online public hearing. The concept was to combine Technology and Engineering together with raising the importance of engineering design to be equal to scientific inquiry.

- Technology is a study of working process to solve, adjust and develop in order to serve the needs of human. The processes of solving the problems or work, in the technological term is called Engineering design or Design process, which has similar process to scientific enquiry. Organizing this learning pattern is a problem-based or project-based learning. Nevertheless, most of the people usually misunderstood that Technology is computers and ICT equipment. In fact, Technology means the process of solving the problems or work in order to create things that serve our needs. In the US, there is International Technology and Engineering Educators Association or ITEEA, who sets the standard of Technology so teachers can teach in the same direction.

- Engineering is a study of creation or innovation or other things that facilitates human’s needs by applying the knowledge of Science, Mathematics and Technological process. However, even in the US, the subject of Engineering is not clearly observable in mandatory education but rather is being covered in the same umbrella as Technology. [1]

- Mathematics is an important subject. It has a clear nature of theory. Mathematics is a subject which can be well-combine with the other three subjects. For organizing teaching and learning, Rakpol Thananuwong (2013) proposed that the integration of STEM Education lies in the learning that link Science and Mathematics explicitly in Engineering Connection. Or it can be said that STEM learning is a design-based learning, which explicitly shown in Engineering knowledge. Integration of the four subjects in STEM teaching and learning requires group practice, discussion and communication skills in order to present the work and result. It is similar to project-based learning, which has been studied that help learners to acquire “deeper learning”. Deeper Learning contains five aspects as follows;

- Mastering Core content
- Think critically and Solving complex problems
- working collaboratively
- communicating effectively
- Self-directed and Incorporate feedback Apart from that, integration of STEM Education is also combine two aspects of teaching and learning.
- Context integration which integrates four subjects together with learner’s daily life in one context.
- Content integration which integrates four subjects together with one “Big Idea”. [2]

5. STEM teaching and learning condition

Artnarong Manosuttitir(2016) researched STEM teaching and learning condition. It was found that there are many factors that require supports and modification. The details are as follows.

1. Educational policy and curriculum: Each school cannot determine the direction and format of STEM instruction because it lack enough information and understanding in STEM education management and there is no clear guidelines provided. This makes each school worried that STEM instruction may affect the teaching and learning of other subjects, especially in terms of limited studying time which is not conducive to any other activities.

2. Integration and collaboration: As there is no clear curriculum and policy, it is not possible to determine details of STEM teaching and activities in term of time, credit, place, and budget. Many schools still have not received financial support or have to use their own budget. This is an ongoing problem that needs to be solved.

3. Responsible teachers: STEM education is a new concept that needs time to understand and adopt. Normally, the teachers already have a lot of responsibilities to take care of. If they are assigned to handle STEM teaching, they will have more burdens and it may have an effect on their daily jobs. Therefore, nobody are willing to take responsibility in this respect. This point should be clearly understood and personnel tasks should be certainly defined.

4. Support from responsible organizations: Many schools carry out their own STEM instruction and activities without correct guidance and support so they are not certain whether what they did are right or wrong. This situation leads to some mistakes in STEM teaching and has an impact on related factors, including place, budget, teaching personnel, teacher training and development, which are all vital to STEM education advancement.

STEM instructional guidelines: The data obtained from the experts and schools in STEM education network can be concluded as follows.

1. Open approach and horizontal learning should be applied. The teachers should control the situation, listen to the students’ opinions, and allow the students to speak, think, practice, and research on their own.

2. Any surrounding topics can be applied to STEM activities, especially in application field as everything is already integrated. STEM activities should be opened without any limitation and should focus on problem-solving methods, concepts, and processes.

3. The teachers of each subject should design the activity together in holistic manner. All involved aspects should not be split and inserted with irrelevant ones. The teachers should emphasize understanding on integration, skills, and ways of thinking.

4. Activities need to be challenging. They should not be too difficult or too easy. The challenge should be moderate and appropriate with environment and restriction.

5. STEM should be used with other instructional activities and teaching methods in order to respond to skill and ability requirements such as using STEM together with project-based teaching to practice 21st century skills, critical thinking, and project executing.

6. Activities should be flexible and suitable for educational environment. They should neither have rigid format nor add burden to the teachers and students. All of the activities should be blended in routine work and inserted in regular class content concerning problem-solving in daily life and practical situation in the community.

From the circumstances and the problems occurred, there were still difficulties that make STEM teaching and learning and activities possible. With many factors that need to be integrated within the four subjects, it takes a huge amount of time in preparation, set up the right time and organize activities for STEM teaching and learning. A case study presents here is in a Computer class in Lower Secondary Level, called “Arduino STEM” which is a project-based activity.
6. Example of Technology application to STEM teaching and learning

Subject: Embedded System Arduino UNO R3 Grade: 8 Times: 40 hrs.(2 hrs/week)

Course Description:
Getting Started with Arduino, Arduino has become much more than just a tool for making, tinkering, and exploring physical and digital interaction, but an entire ecosystem supporting students across all disciplines. Arduino Education is committed to empowering educators with the necessary hardware and software tools to create a more hands-on, innovative learning experience.

Arduino’s one-of-a-kind STEAM (Science, Technology, Engineering, Arts, and Mathematics)

Learning Objectives:
1. Solve problems with process
2. Programming language and can be analyzed by using the computer.
3. Could understand the working principles of Arduino design and function.
4. Responsible. Creative and local resources to apply them appropriately.
5. Designs created by making fantasy computer language properly.

Learning Contents:
- Lecture by media E-learning.
- Reporting group.
- Write a program and control the Arduino board Working with Functions on Arduino IDE Using LEDs.
- Write a program (Automatic Fan, Traffic Light)
- Create jobs Project

Learning Activities:
(Introduction)
1. The students meditate before class and learn about morals in daily life for 2 minutes. Brain Gym
2. The teacher states the learning objectives to the students.

(Instruction)
1. Teacher did the analysis of individual student results to improve their learning and performance.
2. The student did login to Moodle learning platform
3. Teachers make a plan to prepare students to analyze and solve problems with application programs.
4. Teachers teaching about Recommended program "Moodle system and Installing Arduino Using LEDs and App Inventor"

(Conclusion)
1. Ask random students to describe and demonstrate teaching content information from the lecture
2. The teacher separates the students into a team for group activity projects and show Conception Teachers and students to share a summary discussion.

Learning evaluation:
1. Presentation.
2. Quality work project.
3. Quiz

Example of Projects:
7. Conclusion

Although STEM Education has reached Thailand for quite some time and the relating government organizations have tried to push STEM Education’s teaching and learning, in term of policy, personnel and other issues, it is still quite an abstract concept. Thus, it is necessary to study STEM and plan how STEM in Thailand should be. As Sutheera Prasertsil (2016, p.10) suggested evidences in the US shown that in 100 working people, 96 is hired by 4 people and those 4 people are educated in STEM, which is Science-Technology-Engineering-Mathematics. So, the US has tried to propel the education system by using STEM in its fundamental education and encourage STEM to be used in university level. The problems, when compare to the US, that stops STEM Education from succeed in Thailand, is Thai context, teachers’ development and the ability of the teachers to deliver knowledge to learners. Sutheera added that “STEM teachers” need to equip themselves with these necessary skills. [8]

1. Awareness of the patent
2. Knowing various kinds of technology
3. Ability to see Mathematics as representative of Science and Simulation
4. Ability to see assumption
5. Understanding the subject thoroughly
6. Seeking opportunities
7. Understanding systematically
8. Creating a reasoning charts which can be explained by each subject’s content
9. Application of knowledge
10. Five mantras of inventions (Sutheera Prasertsri, 2015)
   10.1. What are the previous inventions?
   10.2. What are the disadvantages of the previous inventions? What needs to be solved? What solution did we choose and why?
   10.3. What principle do we applied to the disadvantages? Why do we choose these principles?
   10.4. How do we apply with our invention?
   10.5. How can we prove that our inventions are better than the previous ones? [9]
11. Understanding liberal arts
12. Ability to sketch
13. Ability to write flow chart of the process with feedback
14. Computational thinking

These skills might only be some parts of the suggestion that STEM teachers should possess, further study and application to each and individual context also need to be done. This, however, needs assistance from many organizations in order to concretely improve Thailand STEM.

8. References

[1] Apisith Thongchhai and et al (2012) Composer. Special Lecture Handout in Science, Technology, Engineering, and Mathematics Education: Preparing students for the 21st Century. by Prof. Dr. Edward R. Reeve, 15 May 2012, at Sanan Sumit Hall The Institute for the Promotion of Teaching Science and Technology
[2] Rakpol Thananuwong (2013) Composer. Training Report in STEM Education by Prof. Mitchell Nathan, 10-11 Jan 2013
[3] Pornthip Siripatrachai (2013) STEM Education and Development in 21 Century: Bangkok University, Journal of Administration. Yrs. 33 ep.2 April-June 2013, p. 49-56
[4] The Institute for the Promotion of Teaching Science and Technology. (2018). Knowing STEM [http://www.stemedthailand.org] Online, [24/6/2018]
[5] Wasinee Itsarasena Na Ayutthaya (2017) Knowledge of STEM Education. Chulalongkorn University Press, Bangkok
[6] National Legislative Assembly. 2015. Report of Policy Recommendation STEM Education Proactive policy Youth development and manpower in science, technology, engineering and mathematics. Online, http://www.senate.go.th/w3c/senate/pictures/comnn/1547 %20stem%20proactive%20policy%20report.pdf [19/6/2018]
[7] Artnarong Manosuttirit (2016). A Study of Teaching STEM Education in Thai High School. Thammasart International Journal of Science and Technology. Vol 21 No.5, 1-6 page
[8] Sutheera Prasertsil (2016). Decode STEM Teaching. Poh Pan Punya Project. Online https://kruyaivijai.wordpress.com/ [9.7.2018]
[9] Sutheera Prasertsil (2015). STEM in Invention: Development of Vision and Imagination. Poh Pan Punya Project Songkhla 2015. Online https://kruyaivijai.wordpress.com/ [9.7.2018]