Learning Design of STEM Education Through Workshop Training for Thai Teachers

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Abstract Learning in the 21st century is a learning that focuses on developing higher-order thinking skills and integrating sciences into a daily life. Therefore, teachers have an essential role in designing learning activities in order to encourage learners to improve problem-solving, creativities and collaborative skills. STEM education is a curriculum based on the idea of educating students in four specific disciplines including science, technology, engineering, and mathematics. These disciplines were integrated into a daily life through an engineering design process consists of 6 steps as follows: (1) Problem Identification, (2) Related Information Search, (3) Solution Design, (4) Planning and Development, (5) Testing, Evaluation and Design Improvement, and (6) Presentation. This paper is a presents teachers' learning activities design through workshops including lecturing, Bionic hand, Floating Restaurant and hand-on activities which are developed based on STEM education to promote as a professional teacher and to respond the learning in the 21st century.

1. Introduction

Science and technology are changing our world at an astonishing pace and rapid. Each country needs to learn and adapt itself to a rapidly changing world. Educational management for developing qualified humans is most necessary. Thailand's education in the 21st century, the government has established a policy to aim creating adequate human resources in order to raise into the country as so-called Thailand 4.0 and developing the country with innovations [1]. The main purpose of STEM education is to integrate STEM disciplines for enhancing students' STEM literacy, which is the application of knowledge to solve the problems, into their daily lives [2]. In the past academic year 2017, the basic education core curriculum in science has been modified to conform with scientific learning in the 21st century. This curriculum aims to develop students' ability to apply the knowledge into a daily life and occupation, also the government has changed the teacher curriculum in higher education according to the changing context. Therefore, STEM education subject is important in developing professional science and mathematics teachers. Because its is integrated 4 subjects, which are science, technology, engineering, and mathematics to encourage the problem-solving, creative, and collaborative skills as well as to involve learning with real problems and concepts of science and mathematics to create products or solutions. Not only do STEM lessons and activities excite young learners, but they also build their confidence and self-efficacy to become successful in advanced math and science [3]. Learning science teachers is important to provide knowledge and learning

management process which focuses on the quality of students. The student-centered teaching methodology is crucial for encouraging students to meet their learning potential and to have the highest learning performance. Teaching professional development is a continuous learning process during the occupation for a teacher. It is to ensure that they have the necessary knowledge, skills, and competencies for the practice of teaching in a social, economic and fast technology [4].

2. Definition and Key Characteristics of STEM Education

STEM Education is a concept in education management that aims to create people with the potential to create innovation. It is a concept that has been used in many countries around the world. However, there are different interpretations and practices among educators [5]. When considering the meaning of STEM, each science has the following explanation and characteristics.

The four strands of STEM; Science, Technology, Engineering, and Mathematics have been stapled forms of all students' academic careers; particularly science and mathematics. They are defined as:

Science: the systematic study of the nature and behavior of the material and physical universe, based on observation, experiment, and measurement, and the formulation of laws to describe these facts in general terms [6].

Technology: the branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science [7].

Engineering: the art or science of making practical application of the knowledge of pure sciences, as physics or chemistry, as in the construction of engines, bridges, buildings, mines, ships, and chemical plants [8].

Mathematics: a group of related sciences, including algebra, geometry, and calculus, concerned with the study of number, quantity, shape, and space and their interrelationships by using a specialized notation [9].

Key Characteristics of STEM education learning activities consist of 6 features: (1) the integration of science, technology, engineering, and mathematics that addresses STEM literacy; (2) designing learning activities based on learning progression framework; (3) providing context-based learning; (4) emphasizing 21st century learning; (5) organizing activities focusing on designing and problem solving; and (6) employing authentic and formative assessment [10].

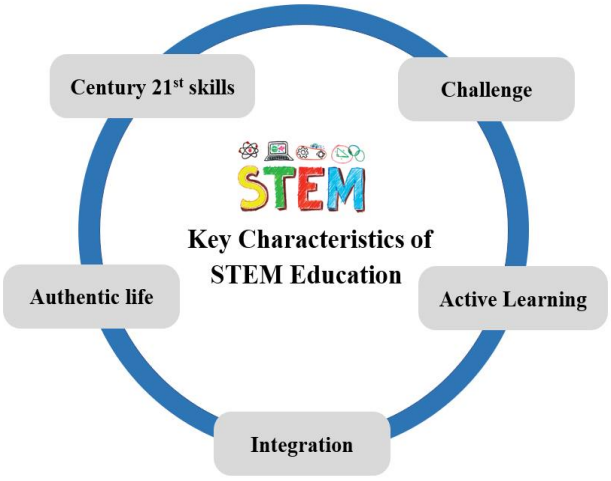

Figure 1. Key Characteristics of STEM Educatio

3. STEM and Engineering Design Process

Many researchers propose an engineering design process as a mean to solve challenges in STEM fields [11]. STEM learning management has adopted engineering design processes to solve problem or to invent innovation in order to allow learners to develop knowledge, understanding and practicing science process skills, and mathematics. The engineering design process has 6 steps as follows [12].

The first step; Problem Identification; defining the problem situations. This problem should be related to daily life or social context which leads to innovative products or potential solutions. Starting with the following questions about problems that you observe;

What is the problem or need?

Who has the problem or need?

Why is it important to solve?

Second step; Related Information Search; searching and collecting information that can be used to solve problems or solutions, through the information process from other learning resources such as the internet, books, relevant person and also searching from knowledge sheets that teacher has assigned and then considering the possibility to solve the problem. The information search should be related to science and mathematics knowledge and other relevant concepts.

Third step: Solution Design; bringing knowledge and related concepts to design or to draft a possible problem.

Fourth step: Planning and Development; planning, defining steps, dividing duties in practices and timing to build workpiece or solutions.

Fifth step: Testing, Evaluation and Design Improvement; checking, testing and evaluating the results of the workpiece or solution and modifying the results to get most effective and suitable.

Sixth step: Presentation; presentation of the concepts and steps to solve the problem of creating workpieces or developing solutions for others to understand and get suggestions for further development of the work.

The using of the engineering design process in STEM education is a tool for teaching and learning of teachers and students to enhance and develop problem-solving skills, higher-order thinking skills, integrating and extending existing knowledge to expand to new perspectives.

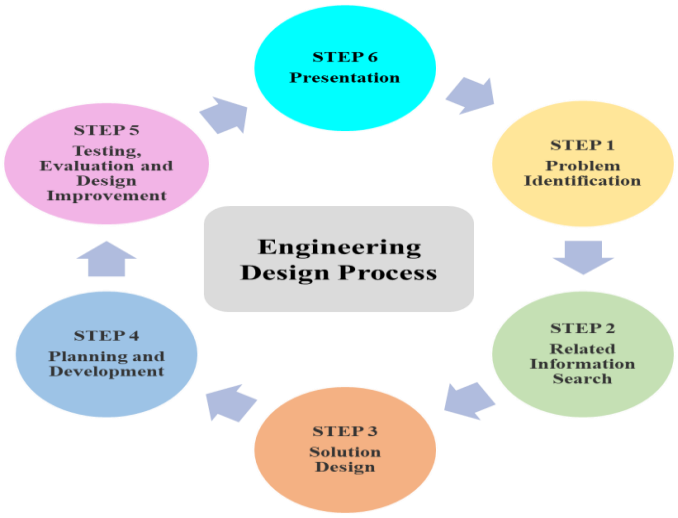

Figure 2. Engineering Design Process

4. Workshop Training Teachers on STEM Education Process

Workshop currently one of the most popular ways for instructions in STEM fields to learn more about teaching and learning [13]. Learning management of STEM education coupled with engineering design, science, mathematics and technology of learners. Real-world problem situation opportunities seem to be a suitable way for students to enhance knowledge, understanding, and scientific skills in sustainability. The engineering design process consists of 6 steps: (1) Problem Identification (2) Related Information Search (3) Solution Design (4) Planning and Development (5) Testing, Evaluation and Design Improvement and (6) Presentation.

The design learning activities on STEM education through the workshop training of Thai teachers for 2 days has been divided into 4 activities;

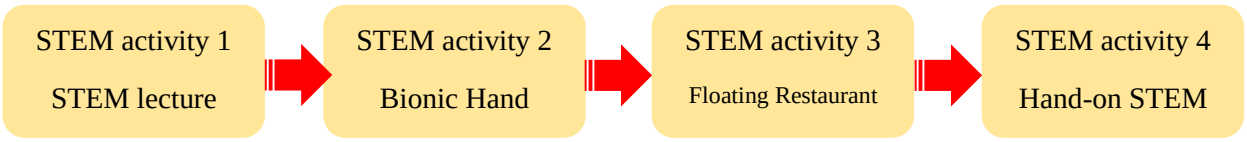

Figure 3. Workshop Training of Teachers on STEM Education Activities

Day 1

Activity 1: STEM lecture

Providing foundation knowledge and understanding and concepts of how to improve teaching and learning of learners in the 21st century skills on STEM education in order to them guide in learning design on STEM education in the classroom.

Figure 4. STEM lecture activity

Activity 2: Bionic Hand

Brainstorming the design and construction of Bionic hand topics regarding the situation on the road accidents, such as drunk driving, doze off, speeding and traffic violation, which cause many disabled people, these are serious barriers in daily life. If the student is a medical engineer, one will design and build an artificial hand, to help those people living can like normal people.

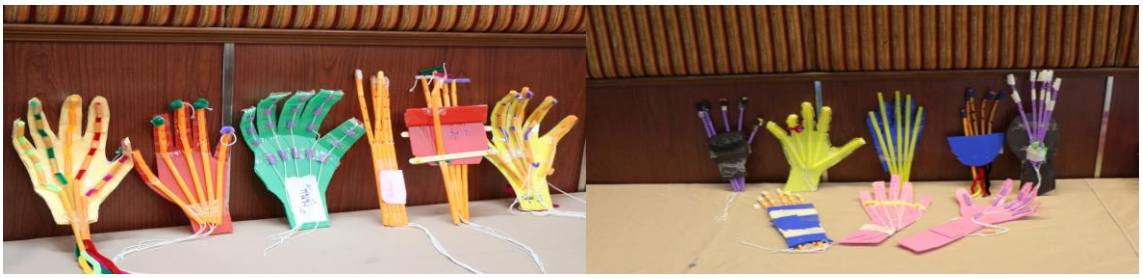

Figure 5. Bionic hand activity

Activity 3: Floating Restaurant

A brainstorming the design and construction of the topic Bionic hand, the issue regarding the situation on the natural attractions. Currently, there are many attractions (for example, the sea, mountains, rivers, streams, and waterfalls) which are popular among tourists. The survey findings revealed the main factors that attracts tourists are food and great atmosphere. It is the places can make travelers feel enjoy the dishes under such atmosphere. Our community has a vast and beautiful river with the great atmosphere. We will have to build a floating restaurant to attract tourists to our communities for improving its economic.

Figure 6. Floating Restaurant activity

Day 2

And activity 4: Hand-on STEM

A brainstorming the design and construction of the prototypes on STEM education that drive teachers to encounter the process of problem-solving skills, creativity, and critical thinking. This activity teachers in each group to brainstorming and discussing to design prototypes and lesson plans on STEM education by using 6-step into engineering design process.

The specified materials follow are as;

1. Papers
2. Feature board
3. Pencil
4. Pen
5. Ruler
6. Double-sided adhesive tape
7. Eraser
8. Doll
9. Glue
10. Scissors
11. Sticky tape
12. Wire
13. Straw
14. Popsicle stick
15. Plastick bottle
16. Foam

Figure 7. Hand-on STEM activity

Table 1. Smart clothesline lesson plan on STEM Education

Problem Situation

Nowadays, It's difficult to predict the change of the season, especially rainy season, It causes musty clothes for many single families, during this season the annoying problem is doing laundry. It is because there is no one at home during working hours to collect the clothes. Thus, the families must dry the clothes inside the house, which may turn the laundry musty and smelly.

Figure 8. The clothes drying problems

Step	Activity
1) Problem Identification	• A teacher ask students : 1. What will happen when drying wet clothes in rainy season? 2. How to dry clothes in winter? 3. How can I dry my clothes quickly after rain? 4. Does rain water make clothes smell and why? • A teacher divides students into a group of 4-5 • A teacher allows each group to design and build an innovative that workpiece help drying clothes, when its rains.
2) Related Information Search	• A teacher and students discuss that 1. How to design and draft clothesline to solve the problem? 2. What possible knowledge to build the information? 3. What are the best clothesline material to use? • A teacher gives knowledge sheets about reels and beams, and force and motion to students to study. • Each group of students brainstorm and understand the knowledge sheets. • A teacher and students discuss about the meaning and the function of reels and beams, and force and motion.
3) Solution Design	• A teacher reviews the problem situations and scientific concetps for each group to design and to select of cost-effective equipment. • Each group design the prototypes on the paper using reels and beams, and force and motion concepts.
4) Planning and Development	• Students the process, assign duties and timing in creating the clothesline. • Students build the clothesline according to the plan.
5) Testing, Evaluation and Design Improvement	• Students test the operation of reels and beams, and force and motion. • Students record the results of the try-out and improvement effective product.
6) Presentation	• Each group of presents the problem and solutions of product. • Students present as following topics 1. What are the reasons for designing and creating the product? 2. How is the product integrated STEM education concepts? 3. What are advantages, disadvantages, and suggestion?

Table 2. The Strongest bridge lesson plan on STEM Education

Problem Situation	
 **Figure 10.** The bridge problem situation	There is a village located on the top of hill. In the morning the mist will cover the area which makes the atmosphere became beautiful and peaceful. However the villagers are facing the problem about travelling. It is difficult to walk since the way to the village is about 300 meter long and 25 meter height. If students are an engineer, how can they build a high bridge which is resistant and able to support the maximum weight?
Step	**Activity**
1) Problem Identification	• A teacher divides into a group of 4-5 • A teacher and students discuss about; 1. Whatt are the problems and barriers of the problem? 2. How can we solve the problem? • A teacher allows each group to design and build the innovation that help the villagers to have the convenient and safe way for traveling.
2) Related Information Search	• Students discuss that; 1. How to design and build the strongest bridge? 2. What are the factors involved bridge construction? 3. What are suitable shapes and materials to build the strongest bridge? • A teacher questions the students about action-reaction force. • A teacher gives knowledge sheets about action-reaction force.
3) Solution Design	• A teacher allows each group to brainstorm the design and the draft of innovation on the paper sheet. • A teacher rechecks problem situations that students must build the strongest bridge which can support the maximum weight. • A teacher assigns each group to present about; 1. What is the design? 2. How to integrate of science and mathematics knowledge? 3. What are used in the design?
4) Planning and Development	• Students pick up the materials which will be chosen to build the prototype bridge. • Students build the bridge and accord action-reaction concepts.
5) Testing, Evaluation and Design Improvement	• Students test the weight support of the bridge. • Students records the results of the try-out and improve the effective product.
6) Presentation	• Each group present the problem and solutions of the products. • Students present as follows topic; 1. What are the reasons for designing and creating the product? 2. How is the product integrated STEM education concepts? 3. What are advantages, disadvantages, and suggestion?

Table 3. Anti-slip slippers lesson plan on STEM Education

Problem Situation	
 **Figure 11.** the accident in the bathroom.	A bathroom is one of the important places that people cannot live without, people many use a bathroom several times a day. A non-standard bathroom can bring dangers to the users. The causes of dangers are a slippy floor and gems. If students are an engineer, how can they build an effective slipper used in the bathroom to prevent the dangers?
Step	**Activity**
1) Problem Identification	• Students watch video about **the accident in the bathroom**. • A teacher divide student into a group of 4-5 • A teacher and students discuss about 1. What are the main dangers in the bathroom? 2. How can accidents be avoided in the bathroom? • A teacher allows each group to design and build an innovation workpieces that helps prevent accident in the bathroom.
2) Related Information Search	• A teacher let students search information about; 1. What is hygienic condition to use bathroom? 2. What is a cleaning equipment in the bathroom sold in the markets? 3. What information is needed to design and build the product? • Each group brainstorm to review knowledge of keeping a bathroom, clean, and friction. 4. What is knowledge can be used to solving the problem?
3) Solution Design	• A teacher allows each group to brainstorm the design and the draft innovative to solve the dirty in the school bathroom on the paper sheet. • Teacher assign each group present about; 1. What is design? 2. How to integrate knowledge of science and mathematics? 3. What is use materials?
4) Planning and Development	• Students plan and create a draft according to the style and materials that in the designed.
5) Testing, Evaluation and Design Improvement	• Students test the anti-slip materials and the design of shoes soles the prevent the accident in the bathroom. • Students record the result and improve the effective product.
6) Presentation	• Each group present the problem and solutions of the products. • Students present as follows topic; 1. What are the reasons for designing and creating the product? 2. How is the product integrated STEM education concepts? 3. What are advantages, disadvantages, and suggestion?

6. Learning management lesson plan related with Science Technology Engineering and Mathematics

The heart of learning design on STEM education activities based on the problem situations linked to real-life and the integration of 4 subjects, throughout scientific explanations, finding accurate information and choosing technology, as well as effective appropriate engineering designs and efficiency.

Table 4. The relationship between Science Technology Engineering and Mathematics

Example 1	Example 2	Example 3
Smart clothesline	Strongest bridge	Anti-slip slippers
Learning Objectives		
Knowledge 1. Students explain the relationship between force and motion. 2. Students explain the relationship between pulley and beam. **Skill/Process** 3. Students design and built the powerful bridge. **Attitude** 4. Students collaborate with group members happily.	**Knowledge** 1. Students explain the scientific principles about action-reaction force. 2. Students know the application of geometry to create a bridge. **Skill/Process** 3. Students design and construct strongest bridge. **Attitude** 4. Students collaborate with group members happily.	**Knowledge** 1. Students know and understanding about bacteria and disadvantage. 2. Students know how to keep clean in the bathroom. **Skill/Process** 3. Students planning design and create innovative. **Attitude** 4. Students collaborate with group members happily.
S = Science		
- Pulleys and beams - Force and motion	- Action-reaction force - Physical properties of materials	- Friction - Herbs - Germs and microbes
T = Technology		
- Searching Information - Choosing the equipments	- Searching Information - Choosing the equipments	- Searching Information - Choosing the equipments
E = Engineering		
- Design and build efficiency clothesline	- Design and build efficiency bridge	- Design and build the patterns of shoe soles surfaces
M = Mathematics		
- Finding area - Angles and sizes	- Geometry - Finding area	- Geometry - Sizes - Finding area

6. Conclusion

This article is the selection of the design hand on STEM activities and lesson plans with engineering design process of Thai teachers through workshop. The learning activities based on STEM education engages challenge, knowledge, ability, and problem-solving process of learners. The problem should be related to a daily life. Therefore, the design of learning activities by teachers have an extremely important role to develop a knowledge, and ability to the respond the 21st century. This effective STEM lesson plans must objectives and evaluation provide in 3 aspects which are 1) knowledge 2) Skill/process and 3) attitude,

the lesson plans should focus on child-centered teaching methodologies. This will fulfill learners' learning potentialities and enhance higher-order thinking skills. Therefore, the learners will be able to in apply the STEM knowledge in their daily life and future professions.

7. Acknowledgements

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