Fighting the terrible paddy fields with safety glasses: STEAM activity design for secondary school students

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Abstract

This research aimed to study STEAM activity designing for secondary school students. The process of the research comprised of four stages as follows ;1) studying concept and relevant literature of both STEM and STEAM educations, 2) PLC activity to comprehend STEM education concept to transform into STEAM education which consists of two specialists in STEM education, one specialist in learning management, and one measurement and assessment of the education, 3) Creating the STEAM education activity i.e. "*Fighting the terrible paddy fields with safety glasses*" activity which was assessed by three experts, and 4) trying *Fighting the terrible paddy fields with safety glasses* activity out with teachers which was observed and assessed by three experts. The results were found that 1) science teachers should understand STEM concept of the integration of Science, Technology, Engineering, and Mathematics. 2) The Engineering Design Process (EDP) which is core of the learning activity was a guideline of problem solving to gain a new thing (product, technology, work piece, or method etc.) by using Science, Technology, Engineering, and Mathematics. Subsequently, teachers have to combine Arts with Science, Technology, and Mathematics into EDP, which is STEAM education, in order to create value and attractiveness of the work piece. 3) Teachers should prepare the STEAM education activity by yourself before teaching the students using Active learning such as Problem-based Learning, Project-based Learning etc. 4) The situation used in the activity should be situation that is found in the student local area to conduce students' compassion causing problem solving with their willingness. 5) Teachers should use the Empathize, the first step of Design Thinking, to acquire of the real problem, by taking the time to understand the problem deeply. 6) Teachers should have PLC activity for STEAM education sharing to prepare/improve the learning activity and

give feedback to students for checking their knowledge and comprehension. 7) Teachers should assess students' learning by authentic assessment.

Keywords: *STEM, STEAM activity design, Engineering design process*

1. Introduction

Nowadays, the labour market trends throughout the world is undergoing a huge hiring problem due to technological advances, an aging society, and lack of resources, including new jobs. Therefore, in the 21st century employment and society, people will need more skills than just knowledge. By preparing for change, the work must have the necessary skills, i.e. complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgment and decision making, service orientation, negotiation and cognitive flexibility [1].

To prepare people for the 21st century, the world of education has changed dramatically in the education of various countries. The goal is to develop students to have skills for living in the 21st century to improve the quality of the population. The various elements that should occur in the students from the educational management in the 21st century. The knowledge that students should comprehend completely, consist of core subjects and 21st century themes, along with skills that students need to have such as1) learning and innovation skills, 2) information/media and technology skills, and life and career skills [2]. Panich suggests that vocational skills and life skills must be studied from primary to grade 6 and university, by studying according to the development of the brain [3]. Teachers must learn how to design Brain-based Learning (BBL) for students of each age group and according to the brain development of each child. Because these skills can't be taught, children have to study by themselves, and teachers have to work harder in thinking and finding ways to design learning. To encourage students are 1) flexibility and adaptability, 2) initiative and self-direction, 3) social and cross-cultural skills, 4) social intelligence and 5) emotional intelligence.

Learning management in schools must, therefore, change from the original. The learning management needs to be adjusted from Passive Learning management, based on content-based teacher-centered learning management, to become an Active Learning Management, based on student-centered learning management, so that students can build knowledge by themselves, with teachers as facilitators [4].

STEM education, another type of Active Learning, is a learning management method that is appropriate and is used for teaching management around the world. It is a guideline for learning that is similar to the learning process of inquiry-based learning, in which students are required to build their own knowledge [5]. STEM education is an integrated teaching across interdisciplinary between the various domains including Science (S) Technology (T)

Engineering (E) and Mathematics (M), which is based on learning management that teachers in many disciplines, because in the actual work or in everyday life requires a lot of knowledge in the workplace. STEM education is a learning management model that promotes the development of skills for life in the 21st century [6].

Later, Yakman [7] developed a model for integrated learning management, STEAM education, which is based on STEM education by adding Arts which recognized the role of aesthetics, beauty, and emotion to arriving at a problem solution [8], and is a complete student development in both sides of the brain [9]. STEAM is the response to emerging problem solving, courage, and critical thinking and tactile skills [10]. Art used can improve pupils' designs, presentations of their material, and increase the efficiency of their creative planning [11].

Therefore, from the above reason, the importance of STEAM education for learners, the researcher is interested in studying STEAM activity designing for secondary school students. The activity design is transformed from STEM education that is appropriate and effective to encourage learners to have creative skills to solve problems from various situations.

2. Objective

To study STEAM activity design for lower secondary school students

3. Benefits

The results of this research give a guideline for designing the STEAM educational activities for lower secondary school students.

4. Research Methodology

The research methodology is divided into 4 steps as follows:

4.1 Study the design of draft STEAM activities based on theory.

The concepts and theories related to STEM and STEAM studies were studied to synthesize the draft STEAM activity. There are 4 steps in studying documents and related research which are: 1) **Defining key words or search terms**, in order to get the exact words that need to be searched to gain the essential information about STEM and STEAM. 2) **Criteria for selecting documents**. There are 4 criteria for selecting documents used in the research, namely; 2.1 *Authenticity* means selecting true documents by examining the

reliability of information about credible sources. There is no discrepancy or distortion from the truth. 2.3 *Representativeness* means the selection of documents that are representative of the same type of document. Subsequently, the information in the document to be analyzed must be representative of the population. 2.4 *Meaning* means choosing documents that are clear and easy to understand. 3) **Search operation**, the researcher searches documents and researches by computer using various Search Engines such as Google.com or Yahoo.com etc. to search for information from various databases and set the year period for searching as needed 4) **Synthesis of studies**, documents and research related to stem studies [12].

4.2 Study the design of draft STEAM activities based on experience by Professional Learning Community (PLC) of experts.

This step was to create a mutual understanding of the STEM learning management approach to lead to analysis and synthesis of the STEAM activities design guidelines along with its evaluation guidelines.

The samples were STEM and STEAM event organizers or learning management experts. The researcher selected specifically consisted of 2 STEM experts, 1 learning management expert, 1 STEM measurement and evaluation expert and 5 instructors in related sciences.

The tools used for data collection were

1) **Record conversation form,** everyone was able to sketch their own activity patterns during the PLC activity.

2) **PLC group discussion**, the researchers gather opinions and find ways to design together used to define the design of STEAM activities. Mover, the research also used PLC audio recording to support design considerations to prevent falling in some details.

4.3 Step of synthesis the design of draft STEAM activities based on theory and experience.

The theories and experiences related to stem studies and steam studies from step **1** and **2** were synthesized the draft STEAM activity framework. The framework was used to create the draft STEAM activity in title of "*Fighting the terrible paddy fields with safety glasses*". The created activity was evaluated by 3 experts. The experts provided the recommendation further utilized to improve the activity.

4.4 Step of leading the improved activity into a pilot implementation.

The improved STEAM activity was tried out with the lower secondary school teachers. During the implementation with teachers, there were 3experts observed the activity to assess activity and give recommendations on various areas that need to be resolved. Finally, the STEAM activity was developed again, leading to be an even more complete activity which was suitable for activity application to further lower secondary school students.

5. Research Tools

Research Tools were as follows.

1) STEAM activity course on "*Fighting the terrible paddy fields with safety glasses*" for lower secondary school teachers
2) Learning plan of the "*Fighting the terrible paddy fields with safety glasses*" activity for lower secondary school students.
3) Record conversation form

6. Data Analysis Method

The researcher analyzed the data by content analysis.

7. Research results

After study of the design of STEAM activities according to the above steps. Results of operations are as follows

7.1 Step 1 Results of document synthesis and research related to STEM and STEAM education and their relation.

STEM education

The synthesis of documents and research related to STEM education found that there are various issues as follows:

1. Learning management according to the STEM education.

Because disciplinary egocentrism includes two factors, negative connection and negative perspective, alternative instructional approaches have been developed. The first is a failure of connections between a fixed discipline and an interdisciplinary subject or problem, causing to limit the capability to integrate between new ideas and practices. The second feature is not only a refusal of other perspectives, but often a failure to recognize differences in perspectives and contributions. It is quite likely that disciplinary egocentrism is as much present in academic staff as the student body and that this may be a factor in the slow adoption of new

pedagogies in any discipline. The term "disciplinary egocentrism", therefore, describes the lack of student willingness to engage in multidisciplinary education [13].

STEM education means integration of learning management in 3 topics: science, mathematics, and technology through the engineering design process. There are 4 level of integration: 1.Infusion Integration 2. Parallel Integration 3.Multidisciplinary Integration 4. Transdisciplinary Integration [14,15]. Improved integration of STEM subjects may not be more effective if there is not a strategic approach to implementation. Building a strategic approach toward integrating STEM concepts needs strong conceptual understanding of how students learn and apply STEM content. STEM education teaching is enhanced when the teacher has sufficient content knowledge and domain pedagogical content knowledge [16]. Therefore, a conceptual framework about learning theories and pedagogies that will lead to achieving key learning outcomes as shown in Figure 1.

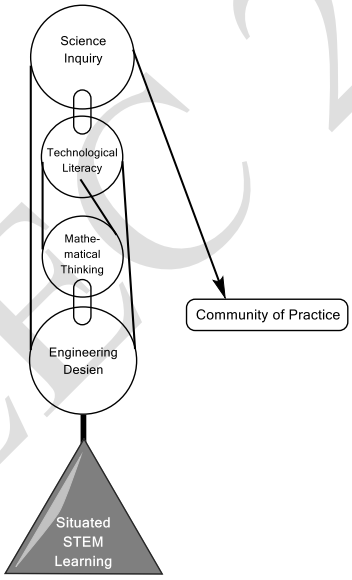

Figure 1. Kelley's graphic conceptual framework for STEM learning.

The Figure shows the proposed conceptual framework for integrated STEM education. Block and tackle of four pulleys which is a pulley system, can lift a load easier due to its mechanical advantage. In this case, the load is "situated STEM learning". Each pulley in the system represents to common practices within the four STEM disciplines, *i.e.* scientific inquiry, technological literacy, mathematical thinking, and engineering design. The integrated system of the STEM disciplines is illustrated by tethering each discipline with the rope of community of practice, to lift a load of situated STEM learning easier [17]. A complex

relationship of the pulley system must effort in congruence to assure the completeness of the whole system. Consequently, STEM teachers should have a strong understanding of the relationship that can be created across domains by engaging a community of practice.

2. Importance of STEM education to students

Learning management along the STEM education encourages 21st century learners' skills. Important factors in the 21st century are 1) analytical thinking skills 2) problem-solving skills 3) scientific knowledge-seeking skills 4) critical thinking skills 5) scientific process skills 6) innovation skills 7) design skills [14,18].

3. Instructional Design Principles

The instructional design principles acquire from the best practices which were found in the Science education and learning Sciences literature. They consist of [19]:

1) Contextualize all student work within STEM-design challenges.
2) Define specific course and unit learning goals.
3) Apply a standardized engineering design process as an instructional framework (as shown in Figure 1).
4) Engage students in practical forms of engineering practices from day one.
5) Assure that all science and math concepts, and technology tools employed are necessary for students' successful completion of the STEM-design projects.
6) Empathize in the school constraints and systems.

4. Measurement and evaluation of learning according to the STEM education

Is an authentic assessment of learners can be done in 2 ways which are 1. In the case that the teacher uses the learning management method **to search for knowledge** (**Inquiry-based Learning**). The instructor can assess the learners as follows: 1.1 Questioning in the test 1.2 Experimental practice 1.3 Report of the experiment 1.4 Study of the variables used in the experiment 2. In the case that the instructor uses the learning management method by **Engineering Design**. The instructor can evaluate the student's engineering design process as follows: 2.1 Brainstorming 2.2 Model development and 2.3 Teamwork [14,20,21].

STEAM education

Furthermore, the synthesis of documents and research related to STEAM education found that there are various issues as follows:

1. Learning management according to the STEAM education

STEAM is a new educational framework which is based on STEM education. Meaning of STEAM education was summarized as follows:

1) STEAM is an educational approach to learning that uses Science, Technology, Engineering, Arts and Mathematics as access points for guiding student inquiry, dialogue, and critical thinking [22].

2) STEAM stands for Science, Technology, Engineering, Art, and Math—a powerful combination of topics and techniques for educating our society [23].

3) STEAM is an acronym that represents how all topics in subject areas relate to each other and to the real world [24].

4) The concept of STEAM education is emerging as a model of how boundaries between traditional academic subjects can be removed so that science, technology, engineering, arts and mathematics can be structured into an integrated curriculum [7]. STEAM is the abbreviation for Science, Technology, Engineering, Art and Math. It's an integrated approach to learning that encourages students to think more broadly about real-world problems [25].

The following diagram was proposed to establish a framework for giving structure to and analyzing the interactive nature of both the practice and study of the core fields of science, technology, engineering, mathematics and the arts, as shown in Figure 2 [7].

The pyramid depicts an interpretation of how all the field of STEAM linked together, and due to it, STEAM became ST∑@M. The new definition of the framework became; ST∑@M: Science and Technology, interpreted through Engineering and the Arts, all based in language of Mathematics.

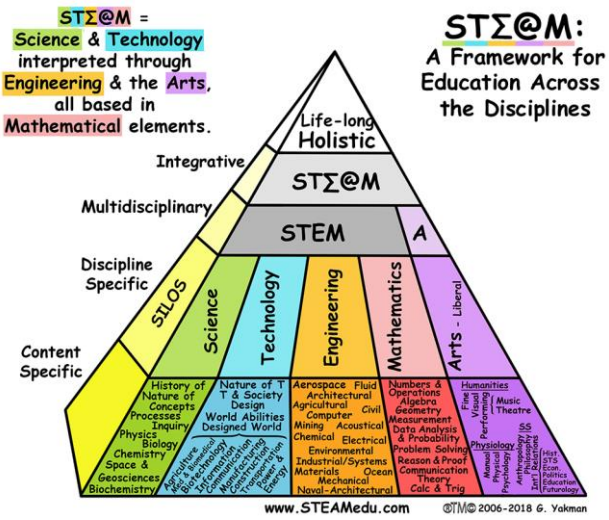

Figure 2. STEAM pyramid

2. STEM turned into STEAM

Guy [26] argues that the 21st century "has opened a new basis for holistic non-linear design of complex systems", and that "systems need to be examined and verified as wholes, which requires a cross-disciplinary approach and new conceptual principles and tools. Subsequently, schools cannot remain to only instruct isolated disciplines based on reductionism". In this complex world, understanding is more important than knowing. Thus, learning by doing is a mechanism for accepting such understanding and that it is time to regenerate creativeness into education curricula. Recently, such calls are not limited to STEM subjects, with the need for creative education in the field of business and management already established [27]. Connor introduces coverage of creativity as well as demonstrating the two-way advantages of integrating Arts and STEM subjects [28].

The liberal arts disciplines were early adopters of such approaches. Duderstadt [29] suggests that an inspection of liberal arts pedagogics may improve the reception of student-centric learning in STEM subjects. A strategy for the integration of arts based pedagogics to promote inquiry guided learning is proposed in STEM subjects [30]. Thus, a model of unbounding the borders between isolated traditional academic subjects such as science, technology, engineering, arts and mathematics, vice versa they were structured into an integrated curriculum, called the concept of STEAM education [7].

3. The meaning of Arts

Arts in STEAM include as follows [7]:

- Language arts (English, ESL,…)
- Fine arts (painting, sculpture…)
- Physical arts (sports, dance…)
- Manual arts (physical skills…)
- Liberal arts (sociology, philosophy, psychology, history, …)

The arts not only helps both students and teachers for achieves of expression, communication, creativity, imagination, observation, perception, and thought, but also open pathways toward understanding the fruitfulness of peoples and cultures that live in real world [31].

4. Importance of STEAM education to students

1) STEAM purposes to strengthen the foundation of STEM by assisting pupils improve their critical thinking skills and recognize the linking of science, math, technology, engineering

and art. It provides students tools and methods to discover new and creative ways of problem-solving, demonstrating data, innovating, and linking multiple fields [32].

2) STEAM education helps students' engagement in transformative learning, based on five interrelated ways of perceptive: cultural selfknowing, relational knowing, critical knowing, visionary and ethical knowing, knowing in action [33].

3) The insertion of the arts element into STEM produces it more fun to learn, and more approachable to kids. A child who has never seen code or computer science learning will be less frightened and more engaged if it includes something they are familiar with, like an art component, whether that is learning it on an interface that uses a creative component to teach it [34].

4) Art learning permits pupils to absorb things in a more open ended way and make them applicable to real life. Arts and creativity, vital to the sciences, technology and computer science, are the tool that allows technology to be practical in real life [34].

5. Instructional Design Principles

This is a list to check the content and activities against to make sure they're STEAM-approved [23]:

- There's a integration between the STEM and the arts content
- Both STEM and the arts are associated and held to equal criteria
- The arts content displays decisively and a way to enhance meaning
- The activity inspires inquiry, problem solving and process-based learning
- You have one of the four 21st century skills: collaboration, creativity, critical thinking, and communication
- Students will apply skills or processes learned from earlier instruction of both standards
- Both STEM and arts knowledge is assessed fairly

After the document synthesis of both STEM and STEAM education, graphic conceptual framework for STEAM learning was synthesized based on adaptation from Kelley's graphic conceptual framework for STEM learning [17] and STEAM pyramid [7] as shown in Figure 3. It shows the proposed conceptual framework for integrated the Art (A) into STEM education. The image displays a block and tackle of five pulleys to lift a load which is "situated STEAM learning" for this situation. Block and tackle is a pulley system which ropes to yield mechanical advantage to lift the load easier. The integrated system is demonstrated by linking situated STEAM learning, engineering design, art, scientific inquiry, technological literacy, and mathematical thinking. Each pulley characterizes the five STEAM disciplines tethered by the rope of community of practice. A complex relationship of the pulley system

must serve in unity to assure the completeness of the whole system. Consequently, STEAM teachers should have a strong understanding of the relationship that can be created across domains by engaging a community of practice.

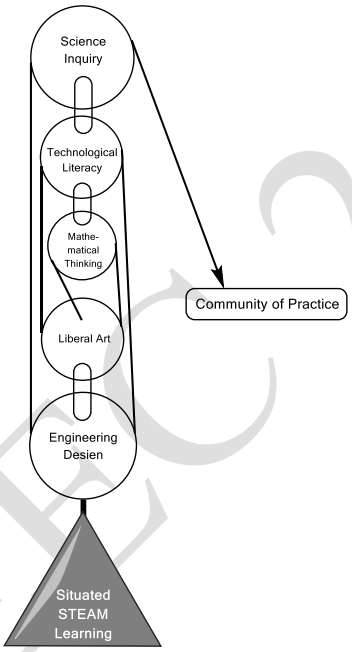

Figure 3. Graphic conceptual framework for STEAM learning adapted from Kelley's STEM

conceptual framework.

7.2 Step 2: Step of study of the construction of the form of the activity arrangement based on experience by PLC activity.

The results of the PLC activity regarding the guidelines for learning management based on STEM education toward design the STEAM education activities on December 12, 2018, on December 12, 2018, at 10:30 am - 5:00 pm, at the STEM Education Room, Building 13,

5th Floor, Sakon Nakhon Rajabhat University. It was found that the essence in the design of the STEAM activities as follows:

1. Definition of STEAM Education

STEAM Education refers to the educational management approach that uses engineering design and integrating Science, Technology, Engineering, Art and Mathematics, in order to solve real life problems.

STEAM = STEM + Arts

2. Meaning of Art

Art integrated with S T E M in the STEAM activity is realized in a broad term. It means not only about creating aesthetics or creating emotions, but also showing cultural expression lifestyle and local context, etc.

3. Understanding the main content of each discipline.

Teachers should study well about the essence of science, mathematics, career and technology. Engineering design process in an integrated manner. Recently, Ministry of Education has concerned the importance of STEM education. Thus, Technology has been included as the forth main content of Science, in which technology has an engineering design process as one of the learning standards [14].

4. Identification of problems in the first step of STEAM activities

Teachers should realize that identification of problems in the first step of the engineering design process in STEAM activities is the first button. If it is stuck incorrectly the next step that follows will go wrong. It is therefore a very important step.

5. Tools to help identifying problems in the first step of STEAM activities

However, there is a problem solving process similar to the engineering design process and is effective in identifying the problem to help teachers, which is Design Thinking, as shown in Table 1. It consists of 5 steps which are: 1) Empathize 2) Define 3) Ideate 4) Prototype and 5) Test.

In **step 1 Empathize**: the importance of defining problems, if you define problems properly, teachers can make them easier to solve, which means saving time, money and resources. Therefore, to understand the problem correctly through taking the time to understand the problem deeply, and then meet the problem precisely. It plays a large role in

determining the right direction in problem solving. Indeed, Understanding the correct problem and asking only the right questions will lead to solving the real problem.

Table 1. The similarities between EDP and design thinking.

Engineering Design Process	Design Thinking
Step 1 Define the Problem	**Step 1** Empathize **Step 2** Define the Problem
Step 2 Collect information	**Step 3** Ideate
Step 3 Design the problem solving **Step 4** Build the model	**Step 4** Prototype
Step 5 Test the model and improve the model	**Step 5** Test
Step 6 Present the guidance of the problem solving	-

6. Determining / identifying problems in STEAM activities

The exact problem is gained, then Determining / identifying problem in STEAM activities written consists of 2 components: 1) Determining the purpose of the solution 2) Defining the conditions of the solution.

1) Determining the purpose of the solution is to regulate whether the solution for something like

- To get the cheapest item
- To give the lightest item
- To give the highest item etc.

In general, problem determination should specify only one objective. The answer of solutions that meet the objective, considered very effective only.

2) The conditions of the solution is to define the rules of problem solving, such as

- Must use local materials
- Must endure heat not less than 80 degrees Celsius
- Must support a minimum weight of 20 kilograms

etc.

Usually, there are many conditions or regulations. But the answer to the solution must comply with all conditions or regulations.

7. Assessing solutions or workpieces designed in the STEAM activity

Teachers should assess students' learning by authentic assessment. When carrying out STEAM activities in accordance with the engineering design process up to step 5 *i.e.* testing, evaluating and revising the solution or work piece. The designed work piece will be evaluated when fulfilling the specified conditions. If conditions are not met, it must be brought to adjust to meet the conditions first. The best workpiece is the work that meets or as close to the objectives as possible.

8. A good STEAM activity

A good STEAM activity that was discussed should consist of:

1) Emphasize issues and problems in real life with integrated art and STEM together to challenge student
2) Use engineering design processes and design thinking to solve problems
3) Emerge students 'questions and surveys to solve problems without fixed answers
4) Enhance students work together as effective teams
5) Have applying students' knowledge of mathematics, science, art and technology they have learned to solve problems.

9. Benefits of STEAM education

1) Learning science and mathematics for students is more interesting.
2) Students have experience in searching for knowledge in science, mathematics, engineering and art, as well as choosing technology to solve problems in real life.
3) Students have a greater understanding of science, mathematics, engineering, art and engineering design processes.
4) Practice problem solving through systematic and creative thinking.

7.3 Step 3. Synthesize the STEAM learning activity plan that is "Fighting the terrible paddy fields with safety glasses" which is improved from experts' advice.

Firstly, study the essence of science, mathematics, technology and the arts in order to be integrated through EDP. The activity was designed based on conceptual framework for STEAM learning adapted from Kelley's STEM conceptual framework (Figure 3). The content level was regard to be suitable for lower secondary education. The glasses were made to test the possibility by myself first until the activity can be done for real

After that, the STEAM activity was designed and sanded to the experts for inspection. In the first draft, the activity name was "*Glasses through the desert crisis*" and the problem situation was "*Students join a treasure trove in a desert filled with the terrible situation such*

as desert storms, hot sun and reflection of the sand. These were a big problems for visibility. Therefore, the survey team leader gave us the mission, in order to create glasses to overcome the desert crisis for everyone to wear. In order to help the treasure survey to be successful, the glasses created must help improve visibility and prevent the dangerous for eyes. There is a modern, beautiful, cheap, practical version".

The experts have suggested that the problem situation should be a close and real problem in the students' community. Thus, **Step 1** Empathize of Design Thinking was used to identify the real problem, and then it has changed its name to "*Glasses through the wide field*" and adjust the situation to "*Students observe people in the community who have vision problems in the community such as conjunctivitis, pterygium, glaucoma, cataracts, etc. The diseases caused from the sun or ultraviolet rays from the sun for a long time or eye irritation, such as dry eyes, eye contact with the external environment such as wind, dust. Therefore students join together to create the safety glasses for everyone to wear in the terrible paddy field. There are the condition as follows: the glasses must be modern, beautiful, cheap, and practical. However, experts have noted that the name of the event is not interesting enough. The name was therefore changed to "Fighting the terrible paddy fields with safety glasses*".

7.4 Step 4: Bring the improved STEAM activity into a pilot implementation.

The activity "*The Fighting the terrible paddy fields with safety glasses*" was operated with 35 science and math teachers on 10 February 2019 at Sakon Grand Palace Hotel, Sakon Nakhon province, Thailand. There were 3 experts observing the operation of the STEAM learning process during the event and then gave recommendations when the activity is finished, that were summarized as follows:

1) Do not demonstrate but must question, in order to enhance the learners to think by themselves
2) Motivate learners to raise their hands with participation for questions and discussion.
3) Experts give an example of asking question: colored sheets that are with students. Try to open it. How is it? (The answer is clear.)
4) Must guide the feelings that students will record in **Step 2** Collect information.
5) There are too many activities in **Step 2** Collect information, causing not enough time.
6) In the **Step 5** Test the model and improve the model, step of evaluating a work piece, you should not vote by sound level. Every student should be involved. For example, if a student would buy which piece of glasses with telling the price (See the criteria specified in the first step)
7) Learners should summarize the knowledge gained from the activities themselves. In addition, this is an evaluation of the activity.

8) From STEM activity, go to see more of Mathematics learning because it was written about Trigonometric ratio, but did not find it in the activity, leading to be unable to evaluate the actual piecework.

After that, the advice of experts were taken to revise the educational management plan for "*Fighting the terrible paddy fields with safety glasses*" and also improve the learning activities, to create the activity design corresponding to the STEAM education. It is appropriately for both knowledge, content and form of learning activities.

Overall, to study on STEAM activity design for secondary school students by using the STEAM activity "*Fighting the terrible paddy fields with safety glasses*" as an example. This was summarized as shown in Figure 4.

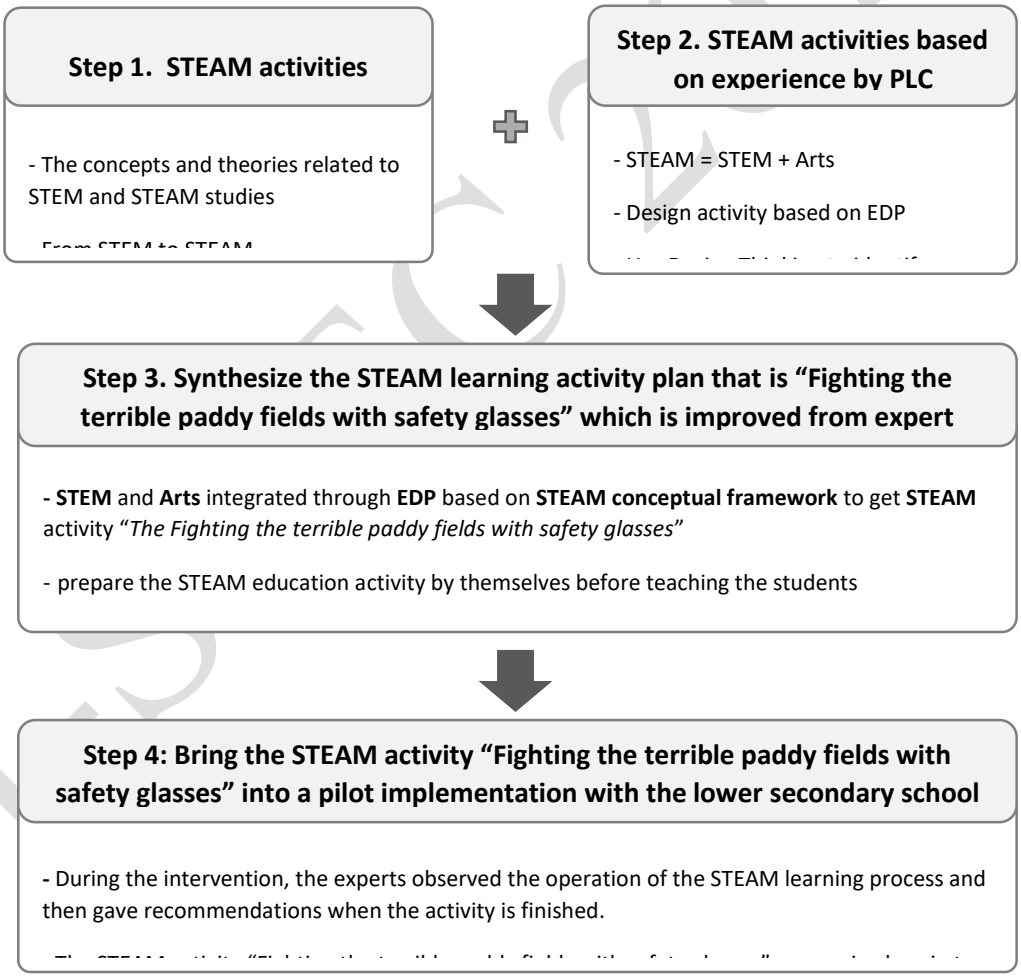

Figure 4 Design of STEAM activity that is "*Fighting the terrible paddy fields with safety glasses.*"

8. Discussion and Conclusions

In designing the integrated STEAM activity and evaluation, the instructors should do as follows:

1) Study the core content of Science, Mathematics, Technology, and the Engendering design process in an integrated STEM disciplines. Therefore, teacher who has an important role in the management of learning along the line of education, need to study and understand the mentioned contents, as well as to include the engineering design process in the form of integration into 3 disciplines [35, 36]. The instructors should utilize the Kelley's graphic conceptual framework as a guideline (Figure 1.) [17], in order to achieve the comprehension of the relationship between disciplines in the integrated STEM education.

2) Use and understand the Engineering Design Process (EDP) which is core of the learning activity because it places emphasis on question such as “What can be developed?” [37]. The EDP is used as a guideline of problem solving to gain a new thing (product, technology, work piece, or method etc.) by using Science, Technology, and Mathematics. Subsequently, teachers have to combine Arts with Science, Technology, and Mathematics into EDP, which is STEAM education, in order to create value and attractiveness of the work piece.

3) Study how to integrate Arts (A) into STEM disciplines to become STEAM, the instructors need to define the meaning of the Arts clearly [31]. Initially, teaches want to transform STEM in to STEAM, the teachers must to recognize the art pedagogics may increase the reception of student-centric learning in STEM subjects [29]. A strategy for the integration of arts based pedagogics to promote inquiry guided learning is proposed in STEM subjects [30]. From STEM to STEAM, teachers need to interpret how all the field of STEAM linked together by using STEAM pyramid (Figure 2) [7], in which Science and Technology are interpreted through Engineering and the Arts, all based in language of Mathematics.

4) Prepare the STEAM education activity by yourself before teaching the students, by using the graphic conceptual framework for STEAM learning, depicted in Figure 3, and synthesized based on Kelley's graphic conceptual framework [17] (represents as STEM education) and STEAM pyramid [7] (represent as holistic STEAM education). The framework is used as a guideline for understanding of the conceptual integrating the Art (A) into STEM education. The created STEAM activity is based on Active learning such as Problem-based Learning, Project-based Learning etc. [36]. After understanding the conceptual integration of STEAM contents, teachers should design STEAM activity by following the steps of design of STEAM activity, as shown in Figure 4. Before organizing learning activities for students, the was improved via a pilot implementation, to study the possibility of an experimental which help the teachers to gain a deep understanding in the

students learning based on STEAM education Consistent with the concept of scientific inquiry.

5) Use the Empathize that the first step of Design Thinking, to acquire of the real problem, because the empathy is at the foundation of human-centered design and essential starting point for any type of design work [37]. Moreover, Design Thinking as a term denotes the cognitive process or thinking skills that designers use to do their works [37,38]. Teachers and your students should take the time to understand the problem deeply, resulting in getting the real problem situation. The problem situation used in the activity should be situation that is found in the student local area to conduce students' compassion causing problem solving with their willingness.

6) Do PLC activity for STEAM education sharing to prepare/improve the learning activity and give feedback to students for checking their knowledge and comprehension. According to Wiwanthamongkon's research [39], it mention that PLC could assist teacher as follows:

- helps teachers with teaching and learning activities

- helps teachers to organize teaching and learning activities more efficiently professional development

- builds academic strength for teachers or those involved in the teaching and learning activities.

7) Assess students' learning by authentic assessment with variety of measurement and evaluation methods and measure many times [36]. There are 2 ways of authentic assessment which are: 1. In the case that the teacher uses the learning management method to search for knowledge (Inquiry-based Learning). Teachers can assess the learners as follows: 1) Questioning in the test, 2) Experimental practice, 3) Report of the experiment, and 4) Study of the variables used in the experiment, 2. In the case that the instructor uses the learning management method by Engineering Design. The instructor can evaluate the student's engineering design process as follows: 1) Brainstorming, 2) Model development, and 3) Teamwork [14,20,21]. Especially, teachers should regard to balancing the assessment between all of disciplines i.e. S, T, E, A and M.

9. Recommendations

1. In order to design an effective STEAM activity that benefit students, instructors should study the conceptual framework, the level of integrated learning management and measurement and evaluation in accordance with the STEAM education to understand deeply.

2. In order to utilize the design guidelines of STEAM activity, instructors should study and understand the content of core areas of Science, Mathematics, and Technology in the core curriculum of basic education 2551 (Revised 2560) to understand deeply.

3. In order to integrate the Arts into STEM to become STEAM properly, instructors should study and understand the core content of Arts in the core curriculum of basic education 2551 to understand deeply.

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