Examining categories of students’ STEM projects in science class

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Abstract. The paper aims to examine Thai high school students’ categories of STEM proposal projects. Participants included 200 Grade 10 students in class 1 - 5 who were learning on science course. Students were asked to apply their science and others to develop their STEM projects as the last part of science course. There were 43 STEM projects from class 1 – 5 which were categorized. Methodology regarded interpretive paradigm. Categories of STEM projects were be interpreted through project proposal, students’ presentation, participant observation and conversation interview. The findings revealed that the 43 STEM projects could be categorized into 8 categories. These included 1) internet of things (IoT) for agriculture business, 2) providing computer knowledge for further development of industry or entrepreneur, 3) providing how to apply scientific knowledge/methods as technology for further development of industry or entrepreneur, 4) providing how to apply scientific knowledge/methods as technology for further development of agriculture business, 5) developing scientific model, 6) making consumer products, 7) making medical products, and 8) technology products for industry or entrepreneur. The most of STEM projects were provided in two categories including the project about making consumer products and projects about providing how to apply scientific knowledge/methods as technology for further development of industry or entrepreneur. This paper may implications for enhancing students to do STEM projects.

Keywords: STEM project, category, science, entrepreneur

1. Introduction
Internationally concerning on STEM education, it could provide knowledge and skills for living in the early twenty first century. In the USA and others, there were some educational policy about enhancing STEM education to prepare the future STEM workforce. And, STEM competencies increasingly required not only within but also outside of specific STEM occupations [1]. STEM skills improving should be provided to meet current and future social and economic challenges. It is considered that STEM skills will shape the innovation and development [2], [3], [4].

To prepare the citizen STEM skills, STEM education pedagogy have been developed. The literatures discussed about what comprises STEM content and practices and what STEM conceptions look like. It revealed some consensus about STEM education pedagogy. These included content and practices of one or more science and mathematics subjects, the providing of engineering practices and engineering design of technologies as the context, the use of scientific and other knowledge as design
justification, learning for the development of 21st century skills, and the context of instruction requires solving a real-world problem or task through teamwork [2], [5], [6], [7].

Another conceptualized idea of teaching and learning in STEM education could be viewed when STEM teaching and learning focuses on processes and engagement of students in collaborative activity. STEM education should not be some teaching is to get through the curriculum or to ensure students achieve well in an examination. STEM learning activities should focus on student center. Students need more scaffolding as they progress through various activities of a process. The practical processes should be occurred within the curriculum (is not extra-curricular), and could be project and/or problem based. The processes could be provided as a way of structuring student activity such as problem based, project based, inquiry, and design. The processes will enhance students to generate ideas, research and investigate, evaluate, model their ideas, identify needs, solve problems, document what they do, and communicate. It is through engagement with these activities that students will learn not only crystalized knowledge but also get to practice the important fluid skills they need for their future. In order to be success on finding solutions or developing prototypes or products, students may develop also some fluid skills such as creative thinking, cooperation in group working, time management, communicate and convince to people; and so on [8].

Sutaphan and Yuenyong [3] argued that STEM education pedagogy should provide student to identify the problem from the contexts – social issues. Then, it should foster students to apply their scientific and other knowledge for problem solving in context of entrepreneurship. Through the problem solving, the engineering and technological process should be provided to enhance students to making something as a solution. They suggested that students not only apply science and mathematics knowledge for solving problem of social issues but also values, culture, designing/procedure knowledge, marketing, financial thing, commence, economic, law, and so on. It could be viewed that students also apply social sciences knowledge for making technological products or some problem solving. It is viable knowledge for human needs. Students require to develop emphatical ability for designing thinking of problem solving because empathy is about understanding the feelings and viewpoints of others. With students’ empathy, they may could apply science, mathematics, and others to design something that feed what human like [3], [9], [10].

Regarding above conception of STEM education, the STEM project may enhance students to learn to think and do something for solving problem by integrating STEM knowledge. And, students may require not only knowledge but also skills in their STEM proposal projects; particularly the learning and innovation skills which is one of 21st century skills. Doing the STEM project in school may allow students learn from working, have an opportunity to practice their capabilities from the beginning to the end such as thinking about the topic of interesting problem, finding the methods to solve that problem properly in the scientific approach, and team work skill.

To develop the ideas of high school STEM project, we have reviewed what the school science project concerned about. It found that the school science projects were categorized into disciplines. For examples, this could be learned from the international (e.g. Intel international science and engineering fair (Intel ISEF), [11]) and national (e.g. the the 21st young scientists project contest [12]) event of school science projects. They provided the 17 categories of school science projects. These included 1) animal sciences, 2) behavioural and social sciences, 3) biochemistry, 4) cellular and molecular biology, 5) chemistry, 6) computer science, 7) astronomy, 8) electrical engineers, 9) energy and transportation, 10) materials engineering and bioengineers, 11) environmental management, 12) environmental science, 13) mathematics, 14) biomedical and health sciences, 15) microbiology, 16) physics and astronomy, and 17) botany. Regarding on Sutaphan and Yuenyong [3] view of STEM education; the STEM projects, therefore, should not only do activity of applying science but also do entrepreneurship activity. These are: (1) the creation of innovative products and markets through transformation of resources [13]; (2) the emergence and development of new firms [14]; and (3) the pursuit of opportunity through risk taking and alertness to asymmetric information [15], [16]. Therefore, this study focuses on categorizing the STEM projects with aiming to shift from practicing single discipline to more integrated practicing knowledge for entrepreneurship activity.
2. Methodology

Methodology regarded interpretive paradigm. The STEM proposal projects were asked developed in order to evaluate students’ applying their science and others after they participated in the intervention of STEM projects in Science course. Then, the categories of STEM projects could be examined.

2.1 Participants

Participants included 200 Grade 10 students in classroom 1 - 5 who were learning on science course in Khon Kaen University Demonstration School (modindaeng), Muang, Khon Kaen, Thailand.

2.2 Method of inquiry

Intervention of STEM projects in Science course was developed through cooperation between school science teachers and university lecturers. The science course was developed for not only learning on science concepts but also applying those concepts for doing STEM projects. The learning activities were provided to support students: 1) to solve some problems with engineering procedures in the activity of STEM study, 2) to create some STEM projects as a solution, and 3) to test and evaluation of their prototypes or products of STEM projects. The lesson plans of science course, which supported students’ developing STEM projects, included 6 lesson plans. Through enhancing students to developing STEM projects, the reflection of school science teachers and university lecturers were provided in order to foster students to not only inquire for scientific knowledge but also practice knowledge for entrepreneurship activity with concerning on human need and empathy.

Then, 43 STEM projects from class 1 – 5 which were categorized. Each of STEM project was labeled by four position number (e.g. 4101). The first number from the left is number 4 that refers to Grade 10. It is represented by 4 because Grade 10 is called in Thai as “Mathayomsuksa 4”. The second number from the left represents the number of classrooms that they are about 1, 2, 3, 4, and 5. The third and fourth number from the left represent the group number in the classroom. For example, 4101 refers to Grade 10 student group 1 of classroom 1. Categories of STEM projects were be interpreted through project proposal, students’ presentation, participant observation and conversation interview. Each categories were highlighted what kinds of knowledge and skills were practiced. And, the final categories were validated and changed through peer debriefing.

3. Findings

It was found that students’ STEM projects could be shifted from practicing single discipline to more integrated practicing knowledge for entrepreneurship activity, and concerning on empathy and human need. They were interpreted and categorized into 8 categories. These included 1) internet of things (IoT) for agriculture business, 2) providing computer knowledge for further development of industry or entrepreneur, 3) providing how to apply scientific knowledge/methods as technology for further development of industry or entrepreneur, 4) providing how to apply scientific knowledge/methods as technology for further development of agriculture business, 5) developing scientific model, 6) making consumer products, 7) making medical products, and 8) technology products for industry or entrepreneur. The most of STEM projects were provided in two categories including the project about making consumer products and projects about providing how to apply scientific knowledge/methods as technology for further development of industry or entrepreneur. The frequencies of each STEM projects’ categories could be viewed as showed in the table 1. And, each category will be discussed then.
Table 1: frequencies of each STEM projects’ categories

| STEM project categories                                      | Frequency | STEM project labels                  |
|--------------------------------------------------------------|-----------|--------------------------------------|
| Internet of Things (IoT) for farming                         | 2         | 4101, 4406                           |
| Providing computer knowledge for further development of industry or entrepreneur, | 2         | 4407, 4507                           |
| Providing how to apply scientific knowledge/methods as technology for further development of industry or entrepreneur, | 15        | 4103, 4104, 4105, 4203, 4207, 4208, 4301, 4302, 4305, 4309, 4402, 4404, 4504, 4505, 4506 |
| Providing how to apply scientific knowledge/methods as technology for further development of agriculture business | 2         | 4501, 4502                           |
| Developing scientific model                                  | 1         | 4202                                 |
| Making consumer products                                     | 16        | 4102, 4106, 4107, 4108, 4201, 4204, 4205, 4206, 4209, 4303, 4307, 4310, 4405, 4408, 4409, 4503 |
| Making medicines products                                    | 2         | 4304, 4308                           |
| Technology products for industry or entrepreneur             | 3         | 4306, 4401, 4403                     |

3.1 Internet of Things (IoT) for farming

STEM projects about internet of things (IoT) for farming could be seen in Group of 4101 and 4406 students’ STEM projects. The highlight of ideas of these STEM projects were provided in the table 2. These STEM projects aimed to develop the precise system of farming through the IoT. The 4101 group designed to use kidbright circuit board to be coded the humidity sensor to precisely control the cacti greenhouse humidity. The 4406 group designed the IoT system to control the temperature and humidity in the mushroom culture in the right environment. The coding through Arduino was developed to provide precision temperature sensor. These projects probably developed students’ mindset of increasing the potential in the agriculture business.

Table 2: STEM projects about internet of things (IoT) for farming

| Group | The topics                                                                 | Objective                                                                                                                                                                                                 | Expected Benefits                                                                 |
|-------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| 4101  | Cacti greenhouse controlled with KidBright circuit board                   | To reduce the risk of cacti absorbing too much or too little water needed.                                                                                                                               | To have a greenhouse that can grow and sustain cacti                             |
|       |                                                                           |                                                                                                                                             | Lots of potential in the agriculture business, and could be expanded further to other types of plants down the line.                                                                                     |
| 4406  | Planting Agaricus pudicus mushroom with Internet of things technology (IOT) | 1. To be able to control the temperature and humidity to provide right environment and duration in the mushroom culture.                                                                                  | 1. To help farmers to reduce the burden of mushroom care and can be applied to other agricultural products.                                                                                                 |
|       |                                                                           | 2. To apply the IoT system in agriculture.                                                                                                                                                               | 2. To get quality of mushrooms and grow them better within the time limit that can be set.                                                                                                               |
|       |                                                                           | 3. To be able to plant Agaricus pudicus in the weather of Thailand all seasons due to the big problem of cultivating this kind of mushroom is able to plant only in the winter. Especially for a small mushroom houses that the temperature changes so quickly. | 3. If this project can actually be used it will be able to save energy in farming.                                                                                                                         |
|       |                                                                           | 4. To reduce the chance of diseases or problems of Agaricus pudicus Caused by culture in an inappropriate environment; for example, a full lump, but do not bloom, the mushroom stalk, cap of a mushroom does not spread. |                                                                                   |
3.2 Providing computer knowledge for further development of industry or entrepreneur

STEM projects about providing computer knowledge for further development of industry or entrepreneur aimed to study about possibility of applying computer knowledge. The results of projects probably provide some information for further development of industry or entrepreneur. These projects were highlighted as showed in the table 3.

Table 3: STEM projects about providing computer knowledge for further development of industry or entrepreneur.

| Group | The topics          | Objective                                                                 | Expected Benefits                                                                 |
|-------|---------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| 4407  | 3D LED PROJECT      | 1. To study about the Arduino board.                                       | 1. Be able to understand about arduino to extend to be an invention              |
|       |                     | 2. To develop the teaching and learning materials with 3D LED PROJECT      | 2. To produce 3D LED PROJECT inventions to be used as educational media for greater understanding. |
| 4507  | Mobile application  | 1. To develop knowledge about Thunkable programs that are used to create applications | 1. To have more knowledge in using Thunkable programs.                           |
|       | for scientific      | 2. To apply Thunkable website as a teaching and learning media.           | 2. To have teaching materials from the use of Thunkable program that promotes teaching and learning programs for users. |
|       | content collection  |                                                                           |                                                                                  |
|       | in lower secondary  |                                                                           |                                                                                  |
|       | school level        |                                                                           |                                                                                  |
|       | through Thunkable   |                                                                           |                                                                                  |
|       | website             |                                                                           |                                                                                  |

3.3 Providing how to apply scientific knowledge/methods as technology for further development of industry or entrepreneur

STEM project about providing how to apply scientific knowledge/methods as technology for further development of industry or entrepreneur aimed to investigate some scientific knowledge, proof some theories, or test efficiency of some methods. These projects probably suggest applying scientific knowledge or methods regarding on market need as showed in the table 4. The results of these projects may provide know how about scientific knowledge/methods that could be further development as technology for industry or entrepreneur. For examples, the 4103 group design to find efficiency of nano-zinc oxide particles effect indigo dyeing clothes that could be further developed in the textile industry. The 4208 group idea of adding iodine in bean sprouts probably suggests some information for some further entrepreneur activities. The 4508 group idea could also provide some information for producing sweet corn industry.

Table 4: STEM projects about providing how to apply scientific knowledge/methods as technology for further development of industry or entrepreneur

| Group | The topics                                                                 | Objective                                                                 | Expected Benefits                                                                 |
|-------|---------------------------------------------------------------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| 4103  | Study in efficiency of nano-zinc oxide particles effect indigo dying clothes | 1. Study the ability to inhibit bacterial growth of zinc oxide nanoparticles | We can apply the knowledge that we learned about a chemicals to use in textile industry, that’s a way to use chemicals to eliminate bacteria. |
|       |                                                                           | 2. Study of the use of nano-zinc oxide in indigo dye that affects the absorption of light |                                                                                 |
| 4104  | Development of recipes that can enhance the growth of the dyed silk in order to form some effective silk. | 1. To develop recipes of high protein Mulberry.                           | A recipe that can strengthen mulberry’s growth to create an effective silk fiber. |
|       |                                                                           | 2. The results of high protein mulberry on growth of the dyed silk and silk form. |                                                                                 |
| 4105  | The study of planting mung bean trees in the simulation of Mars with using water-absorbent polymers providing moisture | 1. To study the growth of mung bean plants in simulated conditions of Mars  | 1. Enable to use the results from the study to adapt to the actual conditions of Mars. |
|       |                                                                           | 2. To study the growth rate of plants in a simulation in Mars with polymers that hold water as moisture. | 2. Able to produce and create some food in the environment of Mars. |
| Group | Research durability of plastic product with appliance | Expected Benefits |
|-------|---------------------------------|------------------|
| 4203  | 1. To extend using time of plastic (thermoplastic) to make a product in order to use effectively. |
|       | Thermoplastics in the household can be melted by using an oven; however, it can be transformed into a product. |

| Group | The project of prevention the Anthracnose in bird-chilli with betal leaves extract. | Expected Benefits |
|-------|---------------------------------------------------------------------------------|------------------|
| 4207  | 1. To study the ability of betal leaves extract preventing Colletotrichum capcisi causing Anthracnose in bird-chilli. |
|       | 2. Betal leaves extract is able to virtually prevent Anthracnose in bird-chilli. |
|       | 3. Betal leaves extract is safe for health and environment. |
|       | 1. Betal leaves extract is able to virtually prevent Anthracnose in bird-chilli. |
|       | 2. Betal leaves extract is safe for health and environment. |

| Group | The study of adding iodine in bean sprouts. | Expected Benefits |
|-------|---------------------------------|------------------|
| 4208  | 1. To study the outcomes of iodine that increases in bean sprout. |
|       | 2. To compare the iodine addition in bean sprouts. |
|       | 1. To get some high iodine of bean sprout. |
|       | 2. To get some healthy products. |

| Group | The project of prevention the Anthracnose in bird-chilli with betal leaves extract. | Expected Benefits |
|-------|---------------------------------------------------------------------------------|------------------|
| 4301  | 1. To study the ability of betal leaves extract preventing Colletotrichum capcisi causing Anthracnose in bird-chilli. |
|       | 2. Betal leaves extract is able to virtually prevent Anthracnose in bird-chilli. |
|       | 3. Betal leaves extract is safe for health and environment. |
|       | 1. Betal leaves extract is able to virtually prevent Anthracnose in bird-chilli. |
|       | 2. Betal leaves extract is safe for health and environment. |

| Group | The study of adding iodine in bean sprouts. | Expected Benefits |
|-------|---------------------------------|------------------|
| 4302  | 1. To study the outcomes of iodine that increases in bean sprout. |
|       | 2. To compare the iodine addition in bean sprouts. |
|       | 1. To get some high iodine of bean sprout. |
|       | 2. To get some healthy products. |

| Group | The development of formulation in order to inhibit mushroom mite. | Expected Benefits |
|-------|----------------------------------------------------------------------------|------------------|
| 4305  | 1. To study the extracts from medicinal plants that can inhibit the occurrence of mites in the mushroom and the efficacy of herbs mixed with metabolic substances that are used to inhibit the growth of mushroom mite in oyster mushrooms. |
|       | 1. The extraction from Tinospora cordifolia and Metabolic substances can inhibit the formation of mushroom mite in oyster mushrooms. |
|       | 2. It is another way to reduce the problem of residue in the mushroom. |

| Group | Study of chemical in orange peel, kaffir peel, and turmeric peel for applying. | Expected Benefits |
|-------|---------------------------------------------------------------------------------|------------------|
| 4309  | 1. To study of chemical in orange peel, kaffir peel, turmeric peel. |
|       | 2. To apply orange’s peel, kaffir peel, turmeric peel as something advantageous in the future. |
|       | 1. To have some chemical from the study of fruit’s peel. |
|       | 2. To have the chemicals to use in future. |

| Group | The sound waves effect towards plant growth. | Expected Benefits |
|-------|---------------------------------|------------------|
| 4402  | 1. To study some effects of sound waves that are related with plants |
|       | 2. To study the results of sound waves towards plant growth. |
|       | 1. To know some disadvantages of plant growth and being related with them. |
|       | 2. To design a set of sound waves to assist in plant growth. |

| Group | Development of bio-fermented products from Neem for inhibition of mealybugs thrips and red mites in guava. | Expected Benefits |
|-------|-------------------------------------------------------------------------------------------------|------------------|
| 4404  | 1. To compare the efficiency of the fermented biological product from neem leaves and the use of chemicals to inhibit thrips - red mites and mealybugs. |
|       | 2. To study the effectiveness of bio-fermented in fermented water each formulation in order to develop products to inhibit thrips- red mites mealybugs from nature. |
|       | 3. It can the hypothesized whether neem plants having insecticides and thrips-red mites. |
|       | 4. To study and continue to make bio-fermented water from neem having the effect of inhibiting thrips. |
|       | 1. To be able to inhibit thrips - red mites by using fermented product Biological from neem leaves without having to spend a lot of money to buy some chemicals. |
|       | 2. To discover how to apply neem plants as a product to inhibit thrips - red mites and mealybugs in guava plants and are easy to produce bio-fermented products from neem leaves with the efficiency of Inhibiting thrips - red mites and mealybugs it is greater than the use of chemicals. |
|       | 3. To apply local plants and and create new inventions and innovations. |
|       | 4. To conserve plants in Thailand and the benefits of herbs. |

| Group | Result of intensity by Malabar leaf in nutrient for growth of Guppy fish (Poecilia reticulata) | Expected Benefits |
|-------|---------------------------------------------------------------------------------|------------------|
| 4504  | 1. To know the appropriate intensity of Malabar leaf in solution. |
|       | 2. To improve and develop the Malabar leaf solution to be a product for treating fish. |
|       | 3. To use and apply the STEAM process for solving problems that are questioning. |
|       | 4. Use the free time to do the useful activities. |
|       | 1. To know the solution concentration of the crude extract from Malabar leaf leaves and Guppy fish grow. |
|       | The most quickly, without disease. |
|       | 2. To create products that can help Guppy fish grow well and do not cause erosion. |
Table 4 (cont’)

| Group | The topics | Objective | Expected Benefits |
|-------|------------|-----------|-------------------|
| 4505  | Development of double-sided adhesive stain removal product from natural extracts. | 1. To study the method of extracting essential oils by steam distillation method. 2. To compare the absorption properties of double-sided adhesive with essential oil extracts from orange peel and kaffir lime peel. 3. To reduce the amount of waste caused by the peel of orange peel and kaffir lime peel to not be wasted. | 1. To know how to extract essential oils by steam distillation. 2. It can compare the efficiency of removing double-sided adhesive stains with essential oil extracts from orange peel and kaffir lime peel. 3. No traces of adhesive stains after removal of double-sided adhesive stains. |
| 4506  | Determination of casein in protein content in various types of milk | 1. To study the most suitable method for separating protein from milk 2. To study the acids from fruits which are used to separate proteins 3. To process the casein protein become to dietary supplements 4. To spend free time to be the most useful. | 1. To know how to separate casein protein 2. To know brand of milk products which have the most casein proteins 3. To gain experience in calculating and comparing acid concentration values 4. To spend free time to be the most useful. |
| 4508  | Development of methods for increasing sweet corn and marigolds production by the way of sound frequency | To study the frequency of sounds affecting sweet corns and marigolds | 1. to gain some knowledge about sound frequencies that affect the growth of corn plants and marigolds 2. To create a set of sounds that affect the growth of sweet corn and marigolds |

3.4 Providing how to apply scientific knowledge/methods as technology for further development of agriculture business

Some STEM projects aimed to provide scientific knowledge/methods for development in agriculture business. These suggest for further development in technology of agriculture products. These projects included study the growth efficiency of rice planting and using chicken bone composition for plant growth. The highlight of these projects were provided as showed in the table 5.

Table 5: STEM projects about providing how to apply scientific knowledge/methods as technology for further development of agriculture business

| Group | The topics | Objective | Expected Benefits |
|-------|------------|-----------|-------------------|
| 4501  | A study of efficiency of rice growth in pot 3 cultivars | 1. To study the growth efficiency of rice planting in pots. 2. To study the rice yields and trees planting in pots. | 1. To be adapted for cultivation in a limited area 2. To be adapted for rice cultivation to produce some products that are suitable for the soil condition in the northeast region |
| 4502  | Result of chicken bone composting in plants for growing | To know about the growth of plants by using chicken bone composition. | 1. This test can be showed to agriculturists for increasing their plant products. 2. To solve lacking of plant product problems by quickening the growth for marketing demands. |

3.5 Developing scientific model

A STEM project was developed with aiming to clarify their understanding through develop scientific model. The 4202 group developed their STEM project about the invention of simulated water turbine producing electricity. They expected that the model of working process on generating electricity could be applied for producing electricity in a house. And, they will teach this model to people. It could decrease safe cost of electricity when people make this model in a house. The highlight of this project was provided as showed in the table 6.

Table 6: STEM projects about developing scientific model

| Group | The topics | Objective | Expected Benefits |
|-------|------------|-----------|-------------------|
| 4202  | The invention of simulated water turbine producing electricity. | To create simulated water turbine producing electricity in order to study of construction and working process | 1. To get the simulated teaching model of water turbine producing electricity for students. 2. To decrease some expense on cost of living |
3.6 Making consumer products

Most of the STEM projects considered on making consumer products. It is not surprising about this. The history of science and technology [17] suggested that new consumer products was created because of practicing scientific knowledge. There are many new products for consumers that appeared in the 20th century such as plastics and nylon proved stronger, more enduring, and more versatile than their natural counterparts. During world war 2, acrylic emulsion technology was developed by Rohm and Haas in the 1940s. It is used for less preparation of household paints. The result was a paint which had low odor, cleaned up with water, was color fast, and resisted cracking and yellowing. Another example is food dehydration technology. Another example is food dehydration technology that used to produce instant mashed potatoes. This technology process was developed in 1960s by the USDA Eastern Regional Research Cente. Then, it was introduced to produced other high-quality dehydrated vegetable products [17].

Like scientists, Grade 10 students have productive of the STEM projects on making consumer products. They designed their thinking to practice knowledge regarding on human need that could be seen when they developed their project for making consumer products. These STEM projects, for examples, included cleaning products from natural materials, the development of paper tape nature-friendly, product of retraining watered microorganism growth, development of fertilizer made from egg hormones, mangosteen soap, natural product for ant repellent, organic air spray, hand cream with natural ingredients, natural supporting pad for deodorant, natural whiteboard pen ink, and so on. The highlight of these project was provided as showed in the table 7.

Table 7: STEM projects about making consumer products

| Group | The topics | Objective | Expected Benefits |
|-------|------------|-----------|-------------------|
| 4102  | The comparison of the efficacy of products from family of Myrtaceae extracts to the obliteration mosquitoes | 1. To prevent dengue fever.  
2. To increase the effectiveness of mosquito repellent products derived from eucalyptus extracts.  
3. To use natural materials productively.  
4. To make use of our free time. | 1. To anticipate the benefit  
2. To expect to receive preventing mosquitoes products from eucalyptus that can be able to prevent mosquitoes as ability and also eliminate from chemicals that are hazardous to lives and environments. |
| 4106  | Product of reducing durian’s odor using essential oil distilled from plants | 1. To compare the deodorization of durian by using essential oils derived from ocimum tenuiflorum, citrus and cymbopogon citratus to deodorize the durian.  
2. To study the extraction of essential oils from ocimum tenuiflorum, citrus and cymbopogon citratus.  
3. To develop products from essential oils obtained from extracting essential oils from ocimum tenuiflorum, citrus and cymbopogon citratus. | 1. Durian can be transported in public places such as electric trains, hotels, and airplanes without causing any disturbance to others.  
2. It could develop into a durian deodorant product and make some money.  
3. This study can be used as a career.  
4. Get essential oils from plants that can stop the durian smell and easy to use. |
| 4107  | The container from Acetobacter xylinum | 1. To learn the amount of sugar that is suitable to feed bacteria (acetobacter xylinum)  
2. To learn the period of time to ferment the cellulose from Acetobacter xylinum  
3. To learn the efficiency of container replaced the foam and plastic using. | 1. A container to pack up the food from natural materials that be able to substitute a container from plastic and foam that have bad effect to the environment  
2. Understand the step to feed bacteria(Actobacter xylinum)  
3. Know the method to make a cellulose from Acetobacter xylinum |
| 4108  | The study of efficiency in cleaning products from lime | 1. To replace cleansing products from chemical.  
2. For use to do not have allergies or bad results to your healthy. | Cleaning products from natural materials. |
| 4201  | The development of paper tape nature-friendly. | 1. To study in making paper tape from gelatin.  
2. To create safe paper tape. | 1. The new invention is nature-friendly and body, also reduce chemicals using. |
| Group  | The topics                          | Objective                                                                 | Expected Benefits                                                                   |
|--------|-------------------------------------|---------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 4204   | The product inhibiting bindweed     | 1. To study Azadirachtin in some neem seeds that can eliminate worms.      | 1. To get a extracting product from neem seeds and sugar apple leaves.               |
|        | leafminers                          | 2. To study the power of sugar apple leaves extract that affects bindweed    |                                                                                     |
|        |                                     | leafminers.                                                               |                                                                                     |
| 4205   | The product of retraining              | 1. To study some extract and examine the                                | The Tannin extract is made of mangosteen and banana peel can restrain watered   |
|        | watered microorganism growth made of | the basic of Tannin in mangosteen and banana peel.                        | microorganism growth                                                              |
|        | mangosteen and banana peel           |                                                                          |                                                                                     |
| 4206   | The development of fertilizer made    | 1. To compare the effectiveness of fertilizer                             | 1. Products that are made of egg hormones and fresh milk hormones can quicken    |
|        | from egg hormones and fresh milk      | made of egg hormones and fresh milk hormones in order to increase the     | the growth of plant.                                                              |
|        | hormones in order to increase the     | green oak fruits.                                                         | 2. To reduce chemical using which is harmful to environment.                      |
|        | green oak                            |                                                                          |                                                                                     |
| 4209   | Produce Mangosteen soap              | 1. To develop formula of the extract of mangosteen peel preventing         | 1. To get some soap from Mangosteen peel extract which can eliminate               |
|        |                                     | Staphylococcus aureus growth.                                             | Staphylococcus aureus.                                                           |
|        |                                     | 1. The comparison of effectiveness in the extract of mangosteen peel       | 2. To find some differences of quality in Mangosteen peel extract of shower jel    |
|        |                                     | preventing Staphylococcus aureus growth.                                  | and Dettol.                                                                      |
|        |                                     | 2. To produce some soup from natural extract and use some resource        |                                                                                     |
|        |                                     | worthily.                                                                |                                                                                     |
| 4303   | Natural Product for ant repellent    | 1. To develop formulation of ant repellent                                | 1. Neem seeds can prevent ants from food                                           |
|        |                                     | product from natural extracts.                                            | 2. to get some herbs that are used to repel ants that are the cheapest and easiest to find. |
|        |                                     | 2. Herbs that are made easier and better than the orange peel.            | 3. Neem seeds quality higher than orange peels.                                   |
|        |                                     | 3. In order not to let ants interfere with some food.                     |                                                                                     |
| 4307   | Produce the organic air spray        | 1. To compare the effectiveness of the air spray from the scent of bergamot, | 1. It can deodorize unwanted smells caused by the smell of cooking inside the building. |
|        |                                     | orange peel and rose that affects to reduce odors.                       | 2. It is able to take advantage of bergamot orange peel and rose.             |
|        |                                     | 2. To study the substances in bergamot, orange peel and rose which have an effect on reducing odors. | 3. The indoor weather has improved. To be creative, spend free time for benefits and harmonize among group members. |
| 4310   | Hand cream Hand made                 | 1. To find the right proportion for making some hand cream with natural    | 1. To get a formula for making hand cream that are suitable for your own preferences. |
|        |                                     | ingredients.                                                             | 2. To learn the properties of substances used to make hand cream.              |
|        |                                     | 2. In order to compare some hand cream that we made with other products    |                                                                                     |
|        |                                     | sold in the market.                                                      |                                                                                     |
| 4405   | The natural supporting pad for       | 1. To study and compare the competence in both of hers to be deodorant.    | 1. Supporting pad can deodorize some bad odor.                                    |
|        | deodorant.                           | 2. The supporting pad can deodorize virtually.                            |                                                                                     |
| 4408   | Production of natural whiteboard     | 1. To study the making of whiteboard ink from natural colors              | 1. Whiteboard pen ink from natural color, can replace the conventional whiteboard pen ink |
|        | pen ink                              | 2. To test the efficiency of using a whiteboard pen from nature           | 2. Whiteboard pen ink from natural colors will not harm the user's respiratory system, and those who inhale. It can be also deleted. |
| 4409   | The deodorant of polluted water with Bath Bomb product | 1. To study Bath Bomb product towards polluted water improvement. | The Bath bomb is able to restrain some bad odor in polluted water.                 |
| 4503   | The product of Thai herbs to inhibit mosquito larvae | 1. To compare the efficacy to eliminate mosquito larvae that use the shortest time with five Thai herbs (mint, sweet basil, holy basil, kaffir lime, and pepper). | 1. To get the most effective product eliminating mosquito larvae that spends the shortest time on working with five kinds of plants (Mint, sweet basil, holy basil, kaffir lime, and pepper). |
|        |                                     | 2. To use the extracts to continue to be the product to eliminate mosquito larvae. | 2. To have the products eliminating mosquis which is nature-friendly.              |
3.7 Making medical products

Some STEM projects were developed to make medical products. They concerned about natural medicences and treatment. These included aromatic medicines from natural herbs and herbal restraint hair loss shampoo. The highlight of these project was provided as showed in the table 8.

Table 8: STEM projects about making medical products

| Group | Topics | Objective | Expected Benefits |
|-------|--------|-----------|-------------------|
| 4304  | Aromatic medicines from natural herbs | In order to study the production process of aromatic medicine from natural herbs in order to be used as a guideline to develop into aromatic medicinal products | 1. To know the process of producing aromatic herbs from natural herbs. In order to develop into fragrant medicine products 2. To get fragrant medicinal products from herbs studied |
| 4308  | The local herbal shampoo product in order to restraint hair loss. | 1. To test the effectiveness of local herbs to nourishment that reduce hair loss. 2. To reduce the risk of chemical allergy and to use more Thai herbs | To get the best herbal shampoo formula that is effective in reducing hair loss |

3.8 Technology products for industry or entrepreneur

Some STEM projects aimed to make products that could be viewed as technology products for industry or entrepreneur. For example, the vacuum sealer from water pressure method could be use for preserve the fresh food production and logistics company. The jar of deceleration of the wither flowers could be viewed as technology product that prepare new flowers’ container of florist shop that provide longer fresh flowers. It could be further developed for florist entrepreneur. The highlight of these project was provided as showed in the table 9.

Table 9: STEM projects about technology products for industry or entrepreneur

| Group | Topics | Objective | Expected Benefits |
|-------|--------|-----------|-------------------|
| 4306  | Vacuum sealer from water pressure | 1. To study and proceed to create a vacuum sealer with water pressure 2. To study the prevention of decomposition from chemical reactions that requires oxygen reaction. If it stores fresh food with vacuum method then can preserve fresh food for longer | 1. To know how to preserve fresh food for longer. 2. Products can preserve fresh food for longer |
| 4401  | The jar of deceleration of the wither flowers | 1. To compare the duration of being wither in flowers with ivy gourd leaves and coffee extract. 2. To prepare new flowers’ container of florist shop that provide longer fresh flowers. 3. To study the deceleration of the wither flowers with natural extract | To get deceleration of being wither in flowers. |
| 4403  | Biodegradable plastic from culturing SCOBY with pineapple fermentation, granulated sugar and boiled water. | 1. To study the optimum ratio to the fermentation of local sour fruits and vegetables, sugar and boiled water for use in SCOBY culture. 2. To study the molding methods of SCOBY into various types of packaging and use appropriately. 3. To study the degradation of packaging from SCOBY | 1. Scoby can be used to improve the quality and can be used as a packaging or a variety of food packaging. 2. Kombucha fermentation can also be made into tea for health and high nutritional value. 3. Food packaging is naturally biodegradable. 4. Use local fruits to make them useful. 5. It is environmentally friendly packaging. |

4. Conclusion

It indicated that the intervention of STEM projects in science course under cooperation between school science teachers and university lecturers supported students to develop the STEM projects. They could shift their designing projects from practicing single discipline to more integrated practicing knowledge for entrepreneurship activity, and concerning on empathy and human need. The intervention supported students’ developing 43 STEM projects that could be categorized into 8 categories. These included 1) internet of things (IoT) for agriculture business, 2) providing computer
knowledge for further development of industry or entrepreneur, 3) providing how to apply scientific knowledge/methods as technology for further development of industry or entrepreneur, 4) providing how to apply scientific knowledge/methods as technology for further development of agriculture business, 5) developing scientific model, 6) making consumer products, 7) making medical products, and 8) technology products for industry or entrepreneur.

Regarding on the 8 categories of STEM projects, they could be viewed what and how students considered on human need and empathy. For examples, students understood the feelings of people who will buy the flower from the florist shop. Then, they designed the jar as flowers' container of florist shop that provide longer fresh flowers. They could provide scientific and mathematic knowledge for designing and testing products. Their STEM projects also could be viewed as their considering on social values. They showed some innovative ideas that could be further developed to the process of developing new business ventures.

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