STEM - Play, Learn and Work: STEM Education in Academic Club Based on Community and Local Products to Improve a Positive Attitude towards STEM

Punyaphat Chaiwongsa¹, Nittayaporn Kinboon² and Nessara Yanasarn³

¹,² Science and Technology Department, Phuwiengwittayakom School, Khon Kaen, Thailand
³ Mathematics Department, Phuwiengwittayakom School, Khon Kaen, Thailand

E-mail : semistar7@hotmail.com, kroonitta@gmail.com, sara11104@hotmail.com

Abstract. This paper developed a practical learning activity named “STEM - Play, Learn and Work” to increases students’ interest and engagement in the learning of STEM (Science, Technology, Engineering, and Mathematics). Because we need to show that STEM knowledge and skills can solve everyday problems and promote community and local products, one popular product in our local community is selected as a representative to be the main theme of learning. We designed the project-based learning activity combined various STEM subjects through steps of production for the representative from the beginning to the end. We used an experimental “STEM - Play, Learn and Work” to 19 students in grade ninth – twelfth in class of academic club. The learning outcomes including student performance and attitude towards STEM are discussed. The assessment results (one assessment taken before the activity, one after) show that the activity improved students’ knowledge in STEM subjects significantly. It also increased students’ positive attitude towards STEM and interest in STEM careers. Students have the opportunity to apply their meaningful STEM knowledge and skills to solve problems in everyday life through this practical activity.

1. Introduction

STEM Education has been in the mainstream of the global learning in the 21st century [3]. It emphasizes on combining different subject areas of science, technology, engineering, and mathematics in a way that integrates them together. Such subjects especially science and mathematics, students cannot link them to apply in real-life problems. This brings to declined Thailand national students’ achievement and negative attitude on the subjects in STEM [6]. Today as never before, in addition to academic subject areas, 21st century interdisciplinary themes are equally important in promoting understanding of academic content. These themes include entrepreneurial literacy, world education systems are failing to adequately prepare all student to succeed life because they are lack of essential skills. One important skill in the 21st century is entrepreneurial literacy [3]. In this paper, we present an example of activity that increases our students’ interest and engagement in the learning of STEM through improving their familiar community and local products that can be accessible easily in their everyday life. As you know, most of schools in Khon Kaen province are located near sources of water for irrigation such as rivers, reservoirs, and groundwater. Ubolratana Dam is the most important one so
that most of students’ families are agricultural or inland fishery families. Fish is one of the main products for this area. By traditional experiences for many years, their family made the popular pickled fish to sell around their community. The process of pickled fish production is complex but interesting. This process can be applied in learning STEM and be explained in STEM knowledge so students get practice themselves in the subject of STEM through this attractive activity and it lets them recognized about their homeland.

2. Related work

Wong and Huen [7] presents a conceptual model to enhance the connection between the knowledge that students learn in school and solving real life problems. They suggests implementing STEM-related activities into the existing education curriculum instead of rewriting the whole courses. Knipprath et al. [4] and Hayden et al. [2] proposed STEM education which aims to foster STEM literacy and a positive attitude towards STEM. The project findings show that students experienced increased interest and attitudes toward STEM. Hauze and French [1] examined the effect on applied STEM education through guitar building.

Mahoney [5] studied students’ attitude toward STEM. The questionnaire was developed for collected students’ attitude. We will adapt it to use in our research.

3. Methodology

3.1. Purpose

The main goal of the activity was to improve STEM knowledge and a positive attitude towards STEM using integrating STEM subjects to real world problems by STEM – Play, Learn and Work model. The activity was designed based on 21st century skills to students who need challenge themselves in academic club class.

3.2. Learning theme and STEM concept design

According to our research objectives, we will develop STEM activity that help to furnish students with STEM related skills and a positive attitude towards STEM so that learning theme was considered by our STEM teaching team using the basis of promoting local community products so that one of community products was selected as theme’s representative. Then the team will provide the fundamental STEM subject concepts related to the selected product and the concepts will be assigned to be responsible by each domain expert in our team. We plan to teach each concept followed by lesson plans consequently by domain experts.

| Table 1. Related STEM concepts for learning theme of pickled fish. |
|-----------------------------|-----------------------------|
| **Concepts** | **Contents** |
| 1. Science | Food science | Acid-base, Food preservation |
| 2. Technology | Computer graphics | Label and logo’s brand design using Adobe Photoshop |
| 3. Engineering | Packaging design | Packaging design |
| 4. Mathematics | Proportion, linear function, volume | Ingredients proportion, Volume calculator for packaging, proportion prediction |

3.3. Activity design and implementation

After we selected learning theme and the concept of STEM subjects, we move to focus on activity design. We need to know how to link STEM subject concepts and our selected local community
product in class. We divide this activity into 3 main steps (Play, Learn and Work). That we will explain in detail as followed.

3.3.1. **Play stage.** In this stage, teacher create interest and generate curiosity in the topic of study. For this study selected product (picked fish) is the key so that students should be asking questions about STEM subject concepts that are relevant to the product and production process of the product. This activity help students to make connections with the previous knowledge.

3.3.2. **Learn stage.** In this study, Learn stage was divided into 2 parts. During the beginning part of “Learn” stage students should be given opportunities to work together without direct instruction from the teacher. In the end part, teachers help students encourage them to explain concepts of STEM subjects in their own word. Teachers use prepared materials to improve students’ understanding.

3.3.3. **Work stage.** They had the chance to apply that knowledge on this stage. Our project-based activity, we inspire them from planning to finishing their output. In this case they need to prepare ingredients to do pickled fish following step by step that they learned from Learn stage. Work stage apply here as well because students should be using the previous information to ask questions, propose solutions, and make decisions and experiment.
3.4. Evaluation method

Student achievement of the 4 core STEM concepts was measured through the deployment of pre- and post-assessments evaluating student knowledge across the 4 core concepts. The data was analysed using descriptive statistics such as mean score, percentage and standard derivation. The overall achievement value of STEM concepts is computed by (1):

$$S_{STEM} = \alpha S_c + \beta T_c + \gamma E_c + \delta M_c$$  \hspace{1cm} (1)$$

where $S_{STEM}$ is the percentage of overall achievement for STEM activity as well as $S_c$, $T_c$, $E_c$ and $M_c$ are the percentages of achievement for concepts in science, technology, engineering and mathematics respectively. This $\alpha$, $\beta$, $\gamma$ and $\delta$ are also the coefficients of $S_c$, $T_c$, $E_c$ and $M_c$ respectively. The STEM teaching team can also define weighted scores $\alpha$, $\beta$, $\gamma$ and $\delta$ to denote relative importance of the subjects; $\alpha$, $\beta$, $\gamma$ and $\delta$ are in [0, 100] and $\alpha + \beta + \gamma + \delta = 100$.

In addition, students’ attitude towards STEM was gathered by giving all of participant students answered the questionnaire which questions expressed in a Likert scale from 1 to 5. We collected the information before activity and after activity in three aspects of attitudes i.e. interesting, ability and values. The data was also analysed using descriptive statistics such as mean score, percentage and standard derivation.

4. Results

At this point achievements and attitude toward STEM were observed for the four content areas of STEM. Student achievement percentages of mean on STEM all subject concept that taken before the activity is less than the one after as shown in Table 2. This show that student achievement of STEM concepts was improved slightly along the activity. The results of students’ achievement taken before the activity for the content areas of science, technology, and engineering are 22.63%, 27.16%, 24.21% and 19.74% respectively and the after one are 70.18%, 73.68%, 68.68% and 56.58% respectively. Among the four content areas, student mean score of technology was consistently the highest in both taken before and after activity. The differences between taken before and after activity were 47.55%, 46.52%, 44.74% and 36.84. The most change of achievement was on the content areas of science. It reached 47.55%. This can be concluded that the activity made understanding of the content of science the most. However, the final overall achievement was calculated by equation [3]. We weighted the coefficients $\alpha$, $\beta$, $\gamma$ and $\delta$ are 25 because the contents of STEM subject are equally important, so that the overall achievements of STEM before and after activity were 23.44% and 67.35%, then the difference was 43.91%. 
Table 2. Mean scores and standard deviations for the achievement of STEM.

| Aspects       | Contents area |        |        |        |        |
|---------------|---------------|--------|--------|--------|--------|
|               | Science       | Technology | Engineering | Mathematics          |
|               | M (%)  | SD   | M (%)  | SD   | M (%)  | SD   |
| Pre-assessment| 22.63 | 3.39 | 27.16 | 3.35 | 24.21 | 3.39 |
| Post-assessment| 70.18 | 3.81 | 73.68 | 2.24 | 68.95 | 2.04 |
| Differences   | +47.55 | 0.42 | +46.52 | -1.11 | +44.74 | -1.35 |

Figure 4. Comparison of Pre-Post-test student achievement on STEM subjects

We also studied the attitude towards STEM using the questionnaire which questions expressed in a Likert scale from 1 to 5. Students' answers to the questionnaire, shown in Table 3, attest that they appreciated the activity. The attitude result taken before activity for interest, ability and value aspect displayed the highest score in technology subject. The post-assessment for attitude shown the highest in technology subject for interest and ability, but the attitude on value aspect the highest score was in mathematics subject. In particular, the students' attitude on value in STEM has been appreciated the most.

Table 3. Mean scores and standard deviations for the attitude towards STEM.

| Aspects     | Contents area |        |        |        |        |
|-------------|---------------|--------|--------|--------|--------|
|             | Science       | Technology | Engineering | Mathematics          |
|             | M (%)  | SD   | M (%)  | SD   | M (%)  | SD   |
| Pre-assessment: interest | 45.61 | 1.01 | 49.65 | 0.56 | 39.82 | 0.72 |
| ability     | 32.11 | 0.41 | 36.49 | 0.67 | 32.28 | 0.76 |
| value       | 57.37 | 0.51 | 59.47 | 0.99 | 57.19 | 0.89 |
| Post-assessment: interest | 78.60 | 0.33 | 83.33 | 0.99 | 62.11 | 0.85 |
| ability     | 72.11 | 0.73 | 74.91 | 0.76 | 64.91 | 0.75 |
| value       | 84.21 | 0.62 | 80.53 | 0.80 | 77.19 | 0.91 |
The difference before and after activity’s attitude on ability aspects for science was the most greatest. The second difference was 38.42% for ability aspect in technology. The lowest difference of the attitude on value aspect was 20.00% in engineering subject. This information of attitude scores told us about the how activity change their attitude towards each STEM subjects so that we can argue that the proposed activity increased students’ attitude on every aspects.
Figure 7. Differences of students’ attitude towards STEM between taken before- after activity

5. Conclusions and future work
This paper presents a developed activity based on STEM subjects. To improve both STEM subjects and local community knowledge, we selected an impact product that be the theme of learning. To analyze the performance of our activities, we will conduct an empirical study among 19 students grade ninth – twelfth. The proposed activity increased students’ positive attitude towards STEM and interest in STEM careers according to the research in [ ], [ ] and [ ]. Students have the opportunity to apply their meaningful STEM knowledge and skills to solve problems in everyday life through this practical activity.

We also expect to continue the activity for other products to expand knowledge on STEM education and local community. In addition, we plan to try this activity on new group of students in other nearby schools, and also improve evaluation method by using multiple experts. Finally we prefer to form STEM professional learning community in our community.

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