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Supporting interdisciplinary instruction on science, mathematics and technology for Thai gifted students: centered on Raiwa lesson plan

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Supporting interdisciplinary instruction on science, mathematics and technology for Thai gifted students: centered on Raiwa lesson plan

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Abstract. This study focuses on teacher development through the continually action workshop of technology-enhanced integration STEM framework. The primary goal was the ambition to integrate active learning activity into national teacher training for gifted classrooms, which is provided by The Institution for the Promoting of Teaching Science and Technology—with teaching practice, aligned with professional development on teacher's understanding of STEM activity. The study aims to identify how teachers develop their understanding of Raiwa-STEM activity, which is shown in their lesson plans. Therefore, the study focused on developing 900 in-service teachers who were science, mathematics and computer teachers that participated in this national teacher training. Data sources throughout the research project consisted of Lesson Plan Assessment, Semi-structure interviews, and document analysis. Interpretive framework was used to analyze the data. Research findings indicate that these research participants who were the teachers work closely with gifted students that have developed their understanding on the Raiwa-STEM activity. Collaboration work among teachers from different subjects encourages them to understand how the STEM activity looks like and how it transfers into an active classroom. After the teachers have experienced with Raiwa activities, they were assigned to develop their classroom implementations which were shown in their Raiwa-STEM lesson plans. From data analysis the teachers can design a connecting STEM lesson into student's daily life, and create evaluation and assessment of the STEM classroom. The development of teachers' understanding and practice is presented in their lesson plans that are produced during training. 75.90 % of the total STEM Lesson plans are of a good level. Moreover, the study also indicates the importance of co-working among teachers from different expertise areas in sub activities preparation that can build interdisciplinary connection of STEM concepts. Raiwa is an example of interdisciplinary instruction which can provide students the use of technology-integrated knowledge and the potential of STEM-focused education to provide all students with the opportunities of STEM experience.

Keywords: Raiwa-STEM Education, Lesson Plan, Teacher Training

1. Introduction

Science, Technology, Engineering, and Mathematics (STEM) literacy is an important element in science related programs of the 21st century. It is STEM education that has probably become the largest reform movement in PK-12 education in the last decade [3]. Including education in Thailand, STEM Education is not a new education trend and is set as a national teaching goal. The Thai government encouraged STEM learning with many national policy plans and increased the number of schools designated as STEM-focus. The Institute for the Promotion of Teaching Science and Technology (IPST) is encouraging the STEM into School based curriculum by providing various workshops and online resources. While the demand of STEM education initiatives across the country is rapidly increasing, the integrated STEM instruction in not keeping place. However, there are several studies that present most teachers do not currently have an appropriate knowledge and do not provide truly STEM based learning experiences, they mainly focused on STEM activities, not reflecting on how disciplinary knowledge integration for problem-solving solution [2], [7], [8]. Similarly, STEM implementation in Thai contexts, Thai teachers do not clearly understand the meaning of teaching STEM. They do not use the STEM activities with their normal instructions, or they use it as a learning project which they provide the students STEM activities for only a couple of days [1]. This difficulty does not appear only in Thailand but also has been found in many countries. These results also point out the common problems which were found in many studies [5], [6]. Therefore, this research is to fill up the gap of how to implement STEM lesson into a real classroom. The professional development is created to build up Thai teachers' capacity to bring STEM into their practices.

2. Context

This study is part of the Development and Promotion of Science and Technology Talents (DSPT) grant. The DSPT project involves partners from higher education and K-12 schools to promote K-12 STEM integration. The goal of the project is to increase student learning of science, mathematics and technology by using an engineering design- based approach for integrated STEM instruction to guide professional development and curricular design. During the teacher training project, 900 teachers who are from 4 groups from Central, North, Northeast and South parts of Thailand participated in 4 days per group. The workshop was provided during May to July 2019. The professional development included a team of instructional coaches to collaborate on the creation of STEM based lesson plans designed with national learning standards of science and mathematics in grades 10-12. These lesson plans were written within the context of real-life situations that have to use engineering design process as problem solving steps.

Raiwa was designed as a theme based on five enrichment laboratory subjects in biology, chemistry, physics, computer, and mathematics. The main purpose of this activity was to stimulate students' high order thinking skills. Students will have to apply some of their knowledge and skills in the subjects they already study to solve a new integrated problem: Raiwa. Students will realize that the content and skills they learned can be applied to solve a new problem. This will help students connect the content subjects to a real world problem. For this research, Raiwa activity was used with the professional development to engage teachers understanding of STEM. The problem requires students to develop an automatic fish pond suitable for the growth of a certain animal in crustaceans named Raiwa. The requirements are:

1. The volume of water in a fish pond and a cesspool should not be less than 2 liters.
2. Raiwa has to be only in a fish pond.
3. The water in the fish pond having Raiwa should have Raiwa's food.
4. The concentration of Raiwa and its food are according to a provided graph between the amount of Raiwa and the concentration of food (Mass/Volume)
5. Light sensor with LDR should be invented to measure the light intensity under the fish pond.
6. The proper condition of the light intensity for Raiwa's growth is seven lux all over the time no matter how the light changes

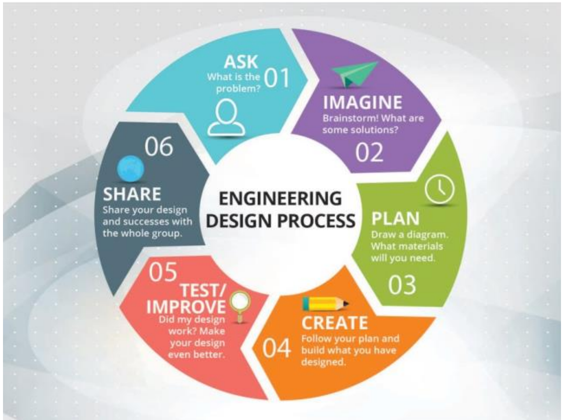
In their first day, teachers learned about challenging problem-solving activities (Forensic Investigator, Stock Exchange, and Worm Robot). The second day of workshop these teachers attended laboratory activities which prepared the teachers to have basic knowledge and skills of Biology, Chemistry, Physics, Mathematics and Computer. The last two days, engineering design processes of Raiwa STEM activities provided teachers to clearly see how to bring STEM integration with their existing learning subjects (Mathematics, Biology, Earth Science, or Physics). On the final day developing and writing integrated STEM lesson plans. Teachers were asked to assess their lesson plans with 6 aspects of characters: a real-world situation challenge; the student-centered instructional environment; using engineering design process; working as a team; using higher order thinking questions; and reflecting how STEM integration was represented.

7. Arduino should be used to control the volume of water in the fish pond and the cesspool with 2 pumps and read the light intensity value.

3. Method

3.1 Research Methodology

This study employs mixed methods which use interpretive study design to increse teachers' practices of interdisciplinary instruction which promotes teachers to integrate STEM in their classes. The data analysis focused on assessing how science teachers develop their understanding and practice of Raiwa-STEM activity. The teachers experienced with Raiwa-STEM activity that relates to concept of Biology (cell counting through smart lens), Chemistry (solution dilution and solution concentration), Physics (light and electricity circuit), Mathematics (logarithm and graph reading) and Computer (coding knowledge). These teachers were challenged with the situation that they had to build the automatic pond for Raiwa which is ideal living things. The teaching and learning processes of this study were followed on this diagram;



Picture 1: Engineering Design Process

3.2 Participants

The 900 teacher participants who were involved in this study were all high school Biology, Chemistry, Physics, Mathematics and Computer teachers. These teachers have experience with gifted classrooms which use DPST curriculum. The teachers were divided into 4 groups and participated in Year 2019 teacher training programs which were held at Kasertsart University, Taksin University, Chiang Mai University and Khon Kean University.

3.3 Research Instruments

In order to study the development of Thai teachers' understanding of STEM, multiple data sources have been used during the research process. Using data from a variety of resources or using more than one method has provided a fuller understanding of this study for the researcher. For this research article, in interpretive case study, individual interview, questionnaire, RAIWA-STEM lesson plan, and group discussion are preferred to assess all teachers' understanding with their thinking, actions, and reasoning in the specific context and setting.

Especially this research article, assessment forms for 498 RAIWA-STEM lesson plans were used by 3 experts per lesson plans. There are 51 items for 6 topics of STEM lesson plans; learning objectives, components, learning concepts, learning processes, learning assessment and evaluation, learning materials and resources. The experts used the criteria which are presented in Table 1 to assess each item.

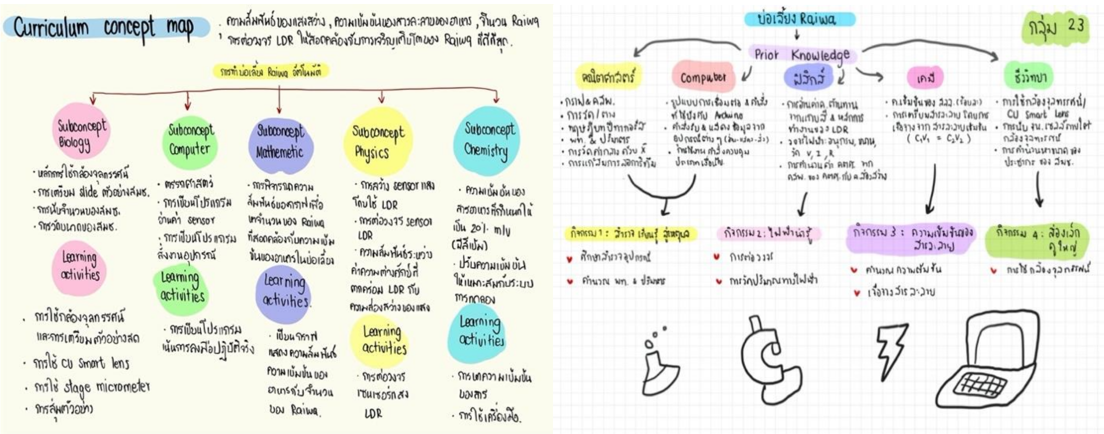
Table 1 the relationship of score levels and quality level of RAIWA-STEM lesson plan

Score Levels	Quality Level	Description
3	Good	Complete component
2	Fair	Partial component
1	Qualify	No component/ Poor component

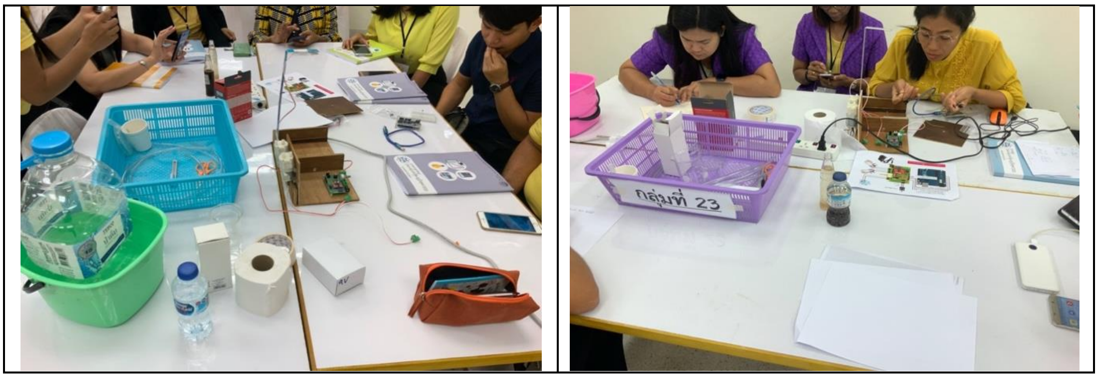
Note Criteria of Evaluation
- Average score between 1.00 – 1.67 score is improvement level.
- Average score between 1.68-2.33 score is fair level.
- Average score between 2.34-3.00 score is good level.

4. Data collection

Data was collected through three research instruments which were used to follow the development of STEM concepts and skills that participants have changed following the Professional development program. Data was collected before, during and after the workshop to present the development of participants' understanding what an engineering design process is and how it should be presented in the classroom as described in picture 1.



Picture 2: Sub-concepts and Main concept diagram



Picture 3: Teacher training with Raiwa-STEM Activity

After the experiment, participants completed a survey which asked the teachers to reflect on the concept and pedagogy of the challenged situation. Second each group created a Raiwa-STEM lesson plan which present how they intended to incorporate the engineering design process with learning and teaching steps of high school classroom. Third, data was collected by researchers who worked as the experts assessed STEM-designed lesson plans. Data from the lesson plans included field notes from one or two observers and completion of a modified STEM Integration Lesson Plan Assessment (LPM).

5. Data Analysis

This study was the development of in-service teachers whose roles were as academic coaches for students who were excellent in science, mathematics and technology. Research data was collected with qualitative and quantitative data. Therefore, data analysis approaches were based on content analysis and statistical analysis. Qualitative data was analyzed to perform real-time changes in the professional development program and to support evaluations of changing of STEM understanding and practice. The researchers observed participants daily written notes at the end of each session for improving the professional development.. The quantitative data was analyzed with descriptive statistics including means, and standard deviations. In developing categories, the researcher used a constant comparative method of analyzing multiple sources of data served to triangulate the data in order to increase trustworthiness of the research findings and assertions made.

6. Result and Discussion

Analysis of evidence from participant reflections and conversations during and after revealed a teacher growth envisioning IPST teacher training as a vehicle for STEM integration by a sequence of professional development design decisions. The evaluation of the integrated learning management plan shows that from 498 STEM integrated lesson plans. Most of them are good and suitable practical plans (75.90%); 14.66% of lesson plans are fair and 9.44% need to improve.

Table 2: Score ranks result of quality of Raiwa-STEM Lesson Plans

Score Ranks	**Raiwa-STEM Lesson Plans**	**Quality Level**
	Number (percentage)	
1 – 75	47 (9.44%)	Qualify
76 – 121	73 (14.66%)	Fair
122 – 153	378 (75.90%)	Good

According to the learning journal, it was found that teachers have explained the engineering design as a process of solving problems or meeting various needs. However, there are other explanations of engineering design from Raiwa activity as evidences below.

"Identifying a challenge is a step away that a problem solver understands what the problem is in daily life. It is the way to understand the problems or challenges; to analyze conditions or limitations of problem situations in order to determine the extent of the problem which will lead to the creation of pieces of work or methods in solving problems" (T1)

"Data gathering and related information search is a collection of information and theories in science, mathematics and technology related to the problems solving approach and assessing the feasibility, advantages and limitations" (T1)

"Solution design is the application of relevant information and theories. For the design of pieces of work or problems solving methods taking into account the resources, limitations and conditions of the situation" (T3)

"Planning and development are a step-by-step method for creating work pieces developed for problems solving methods" (T4)

"Testing, evaluation and design improvement of solutions to problems or specimens is a test and evaluation of the performance of the work piece or method by which the result may be used to improve and develop to be the most effective solution" (T4)

"Presentation of problems solving solutions is a procedure of solving problems for creating work pieces or developing methods for others to understand and can suggest for further development" (T4)

7. Conclusion

The purpose of this professional development was to support teachers to have a clear experience of STEM designed activity and to implement in real classroom contexts. The experience was provided by using hands-on training and participating in the design of a STEM lesson plan. From the study, it shows that Raiwa activity is a good example for teachers to create an integrated unit for students. For the five enrichment laboratory subjects, students learn the content and laboratory skills in each subject as well as their application to a real world situation. Raiwa shows students a case where different knowledge and skills in varying subjects can be used to solve a real problem. This activity is suitable not only for teaching students' high order thinking but also modelling students to be able to collaboratively work as a team. To support teachers to create activities to motivate students' learning, Raiwa is an intriguing activity. Teachers has to work as a team to design activities to allow students to be competent in problem-solving skills with prior knowledge and skills the students already possess. Teachers will have a chance to choose content and skills necessary in each subject to create an integrated lesson plan. A discussion among each group of teachers to present their ways of solving the problem and a lesson plan will broaden teachers' perspective about how an activity can be created differently based on teachers' knowledge, skills, and experience. Teachers will realize that the new activity can be invented based on what they already know. It is not difficult at all to create a lesson to let students think critically and creatively.

The results present that the teachers who participated had a better understanding of the definition of STEM education and are able to design teaching procedures that reflect an understanding of the engineering design process. By working as a team for solving the problems during this workshop, participants were challenged to experience Raiwa activity and to question their conceptualizations of STEM from prior professional development experiences. These teachers reflected on their own changes which regarded STEM education as a teaching and learning approach that can be linked to the national learning standard and also can be used during normal class time, not only through science/ mathematics camps. Many teachers mentioned that shifting roles between students and teacher during the workshop allowed teachers to connect their STEM teaching with the existing lessons. University facilitators also coached the teachers in real-time of planning, reflecting, and revising as they gauged participant perceptions and responded to participant challenges to connect concepts to practice. The quality of the Raiwa-STEM lesson plan developed by the teachers present that these teachers developed their understanding of STEM instruction. When teachers analyzed and applied integration tasks to incorporate STEM design characters, they presented multiple ways within these problem-solving steps and reflected on their implementation. The construction of a reasonable and realistic STEM orientation for teachers is critical as the education community looks toward broader engagement with STEM in classrooms. In addition, it presents they can design their own STEM lesson plans for implementing in classrooms. Additional, engineering activities are applied using project-based instructions. According to Lantz [4] stated that the engineering element of STEM education helps students explore mathematics and science in a more independent way, while helping them to develop the critical thinking skills that can be applied to all facets of their work and academic lives. Engineering is a method that students utilize for discovery, exploration, and problem solving.

Raiwa activity is a good example for teachers to create an integrated unit for students. For the five enrichment laboratory subjects, students learn the content and laboratory skills in each subject as well as their application to a real world situation. Raiwa shows students a case where different knowledge and skills in varying subjects can be used to solve a real problem.

Research Implication

The findings guide Thai teachers to initiative STEM based activity and also guide them to create their own STEM lesson plans based on the national learning standard. Therefore, a future professional development program should have followed up steps with the teacher school-based context.

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