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Enhancing Pre-Service Teachers' Integration of STEM Education into Home Economics Lessons Through A Professional Development Program

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Abstract

This research was aimed to assess whether a newly developed professional development (PD) program enhances STEM-based teaching practices among pre-service home economics teachers. The activities in this PD program were divided into three parts: knowledge about STEM education, lesson plan development, and implementation of STEM-based lessons. Using three pre-service home economics teachers as case studies, data were collected throughout the PD program from group discussions, observations, interviews, and review of documentation. Data were analyzed using content analysis. The findings demonstrated that the pre-service teachers gained more confidence with integrating STEM education into their lesson plans as a result of the PD program. In addition, they were able to link content about home economics to other disciplines. This integration provided more opportunities for students to test their own ideas, ask questions, and apply 21st century skills. STEM knowledge, school context, students' learning style, and time constraints were identified as the main factors that impacted their teaching practices. Results from this study provides insight on how to better prepare teachers outside of the STEM disciplines with integrating STEM content into their teaching practices and provides a framework for future research.

Keywords: teacher practices, STEM education, professional development program

1. Introduction

In Thailand, there are national efforts to transform society to a new economic model, known as the *"Thailand 4.0"* policy, which is focused on promoting creativity, innovation, new technology, and the availability of high-level services (Baxter, 2017). STEM education, a pedagogical approach that integrates Science, Technology, Engineering, and Mathematics, is considered a critical component to this transformation, as it provides the best opportunity to prepare the new generation of Thailand's workforce in several sectors, including industry, health services, environmental management, logistics, and transportation. The Thai government encourages all schools to implement STEM education into their curriculum, which should include project-based and problem-based STEM learning activities that provide students the opportunity to solve problems in daily life, as well as challenge them to seek alternative solutions (Boonruang, 2015).

These efforts can expand beyond the implementation of more STEM-based courses. For example, STEM education can be integrated into Home Economics curricula, which includes the area of consumer science, nutrition, food preparation, parenting, early childhood education, family economics and resource management, human development, interior design, textiles, apparel design, as well as other related subjects. Home Economics provides an ideal opportunity to demonstrate STEM in action (Wesley, 2015). Within both these areas, students focus on real world lessons and problems, immerse in hands-on inquiry and open-ended exploration, participate in productive teamwork, apply the engineering design process, integrate content from Math and Science courses, and experience failure.

Unfortunately, many pre-service teacher programs do not incorporate any STEM training, and STEM concepts are often ambiguous among teachers, particularly for those who teach outside of the STEM disciplines

(Lederman & Lederman, 2013). To address these issues, PD programs in STEM education are imperative to assure that teachers are prepared to effectively implement this educational reform. According to the literature, an effective PD program should offer different forms of media for presentation and delivery of materials, as well as make training practical, relevant, hands-on, and interactive (Burgstahler, 2006). Furthermore, a successful PD program should be able to accommodate individual needs (Darling-Hammond & Sykes, 1999), allow sufficient time, offer on-going professional support (Radford, 1998), and provide easy access to all the necessary resources (Loucks-Horsley et al., 2003). Gains in both knowledge and perception require time and persistence (Loucks-Horsley et al., 2003). The process of change can only occur when the teachers are confident about the outcomes of teaching strategies (Bell, 1998). Teachers must recognize a need, make plans to address this need, actively engage in improvements, and allow sufficient time to evaluate the efficacy of the new practices (Boling & Martin, 2005). Sikes (1992) suggested that with this process of change, teachers should be required to continually alter their administrative and organizational systems, their pedagogy, curriculum content, the resources and technology that they use, and their assessment procedures.

In order to address the specific needs of pre-service home economics teachers with integrating STEM education into their teaching practices, the researchers designed a PD program that was tailored to enhance STEM teaching practices within the context of home economics education. Here, we utilized 3 case studies to assess whether this newly developed PD program improves STEM-based teaching practices among pre-service home economics teachers.

2. Research Questions

Using three pre-service home economics teachers as case studies, this research seeks to address the following questions: (1) What changes in STEM teaching practices occurred as a result of participating in the PD program?, and (2) What are the factors that constrain or facilitate STEM teaching practices within the context of home economics education?

3. Research Methodology

Interpretive paradigm was the research methodology utilized in this study, which attempts to understand and explain human and social reality through the subjective experiences of the individuals (Crotty, 1998). The researchers interpreted the experiences of three case studies with the goal of gaining a better understanding of how the teachers changed their teaching practices with respect to STEM education as a result of participating in the PD program, as well as to examine the factors that have constrained and facilitated their STEM teaching practices.

3.1 Context of the Study

The context of this study is to evaluate the efficacy of PD program in STEM education designed for home economics teachers. This research was conducted at a teacher-education institute in Bangkok, which has a commitment of generating and developing pre-service teachers of high quality and standards sufficient for high vocations. The five-year program graduates teachers with the basic qualification of a bachelor's degree.

The PD program was designed as an extracurricular activity to expand on the knowledge of pre-service home economics teachers' by promoting the construction of new knowledge in the area of STEM education (Bell, 1998), providing situations for them to reflect on practices (Richardson & Placier, 2001), providing a follow-up phase to check teachers' progress (Fetters et al., 2002), using activities that reflect how they teach in the classroom (Loucks-Horsley et al., 2003), and implementing multiple strategies for development (Loucks-Horsley et al., 2003). During participating in the PD program, pre-service teachers engage in various activities, such as discussion, presentation, self-reflection, observation, interviews, exchanging ideas with guest speakers. The PD program comprised three parts. In Part I, they were provided an introduction to STEM education during a one-day meeting, which covers: 1) the definition of STEM education; 2) the importance of STEM education, 3) the role of technology in STEM education, and 4) and teaching strategies in STEM education. In Part II, they were given two examples of STEM education in the classroom, the tall tower challenge and the edible car. In Part III, they were asked to develop lesson plans in STEM education that integrate concepts in home economics. The researchers also asked them to present their developed lesson plans in order to give them suggestions on how to improve on their STEM-based home economics lessons.

Prior to implementation during the second semester of the 2017 academic year, the PD program was reviewed by three experts, which included a scientist, a science educator and an experienced teacher. During the study, the researchers acted as facilitators who asked questions to clarify any points that participants did not understand. Typically, the discussion took at least one hour per meeting.

3.2 Study Participants

Somsak, Veera, and Somsri, all pseudonyms, were the three case studies. All of them were fifth-year pre-service home economics teachers from a school in Bangkok during the 2017 academic year. These three cases were selected from 7 pre-service home economics teachers to participate in the PD program based on three criteria: 1) they were interested in STEM education, 2) they volunteered to participate in all activities in this PD program, and 3) they demonstrated the intent to link their teaching home economics content to the daily life.

3.2.1 Case I: Mr. Somsak

Somsak was a 24-year-old man. He was interested in learning and applying new ideas in his classroom. At the time of this study, he was responsible for teaching Home Economics, which was an additional subject for grade 8 students. For this research, he wanted to focus on the sawing unit, which included one teaching period per week for eight weeks total. There were 40 students in his class. Many of them did not pay attention, and some of them were consistently absent. He had no experience with STEM education. His reason for participating in the PD program was his desire to develop his teaching skills and to gain potential benefits from participating in this research.

3.2.2 Case II: Mr. Veera

Veera was a 23-year-old man. He tried to apply new ideas into his teaching practices. At the time of this study, he was responsible for teaching Home Economics, which was an additional subject for grade 10 students. For this research, he wanted to focus on a Thai dessert course, which he taught two periods per week for three weeks total. There were 6 students in this program. He felt that most of his students did not have inner motivation in learning. They were quiet and did not ask questions in the classroom. He had no prior experience with the STEM teaching approach but he did learn about STEM education in seminar course, which made him more knowledgeable before participating in this PD program. He would like to learn STEM teaching approaches that he can apply in his classroom.

3.2.3 Case III: Miss Somsri

Somsri was a 22-year-old woman. She was enthusiastic to learn new things. She taught grade 11 in the Food and Technology program. In this study, she selected the food preservation unit to link with STEM education. She taught two periods per week, with a total of ten periods for this unit. There were around 6 students in this program. Most of her students did not have inner motivation in learning. They were quiet, did not ask questions in classroom. She had no experience with the STEM teaching approach. She decided to participate in the PD program because she thought that her students would greatly benefit from this teaching approach.

3.3 Data Collection

The researchers collected data using various methods from participants before, during, and after participating in the PD program. Prior to participating in the PD program during the first semester of the 2017 academic year, Somsak, Veera, and Somsri were asked to complete an open-ended questionnaire to examine their knowledge of STEM education. The questions related to the definition of STEM education, characteristics of STEM education, strategies of teaching based on STEM education, and learning assessment related to STEM education. After that, they did activities in 3 phases of the PD program, as described in the *"Context of the Study"* section, during the school break of the 2017 spring semester. During each meeting, they were asked to describe their experiences on various topics related to the PD training. The researchers also asked each case for permission to videotape the discussions. In addition, the researchers conducted semi-structured interviews both before and after participating in the PD program to evaluate changes in their STEM-based teaching practices. The researchers also used an informal 25-30 minute interview for additional clarifications.

Classroom observations were also conducted in the second semester of the 2017 academic year. The three cases implemented their developed lesson plans in their classrooms. The researchers focused on how they implemented their STEM integrated lesson plans in their classrooms, as well as any factors that constrained or facilitated their practices. To avoid inaccurate interpretations, the researchers recorded contextual details in field notes, such as names of participants, location, duration, activities and opinions. For document review, they case studies were asked to write journals, document their developed lesson plans, and complete their classroom worksheets. They were also encouraged to explain what they wrote, and expand on their thoughts and ideas if the researchers still had some unclear points.

3.4 Data Analysis

The data from all research instruments were analyzed using content analysis. The researchers read raw data for

interpreting and constructing categories to capture relevant characteristics of the documents' content. The coding was validated by a panel of educators. Four criteria were utilized to establish trustworthiness of responses in this study, which are outlined by Lincoln and Guba (1985). The researchers increased dependability by describing and explaining the assumptions and theory behind the study, and how the data were collected in detail. Reliability was assessed using an independent audit process conducted by educational experts. The details about the data collection, coding and analysis were examined and reviewed by experts to give the researchers feedback on their points of view and accuracy. To enhance transferability, the researchers included rich details regarding the STEM-based teaching experiences of the case studies.

4. Findings

4.1 The Pre-Service Home Economics Teachers Changed Their STEM Teaching Practices as A Result of Participating in the PD Program

4.1.1 They Tried to Link Their Home Economics Content to STEM Disciplines

Before participating in the PD program, Somsak, Veera, and Somsri lacked confidence with integrating other disciplines into their teaching because of their limited knowledge in disciplines outside of Home Economics. For example, Veera revealed in a questionnaire, *"I am not sure that I can use STEM education in my class because my basic knowledge about STEM is not enough. I think that Engineering is difficult for me."* Similarly, Somsri pointed out during a group discussion, *"Sometimes, I do not feel confident because I am not good in Science."* In addition, all of them also admitted that they had not integrated other disciplines into their teaching. They focused their lessons on home economics, as shown in Somsak's learning objective of lesson plan: *"1) Students can identify the equipment used when sawing the button. 2) Students have skills in sawing the button, and 3) Students are attentive in learning and actively participate."*

However, after participating in the PD program, all case studies discovered that home economics do connect well with STEM education, and they tried to design their lessons by integrating STEM concepts. For example, Veera developed a STEM lesson with the topic of *"Glutinous rice balls in sweet coconut milk ... The first step for the job"*. His students learned about the change of substances as a result of chemical reactions. He used the boiled flour as an example of these changes that students could learn through observation. He introduced technology through the equipment used to cook glutinous rice balls in sweet milk. The students used the engineering process to create glutinous rice balls that were not round. They had to create other shapes that could be cooked with the equipment. The mathematical concepts of weight, measurement, and shapes were linked to his lesson. Throughout his lessons, he asked his students to reflect on STEM concepts during these activities.

Somsak used the topic of sawing to integrate STEM education. His students learned about force while using the sawing equipment, such as needles and scissors. His students used engineering process to create a bag from fabric to carry a minimum weight of five kilograms. The concepts of measurement, pattern, size, weight and geometry were linked to his lesson. He also provided a worksheet for his students to complete about STEM-related concepts as they engaged in these activities.

Somsri designed her STEM lesson around the topic of food processing. Her students learned about preservation and the equipment utilized for food preservation. Her students used the engineering process to create a new product from a sweet potato that can be stored for a long time. Measurement, shapes, and portion sizes were integrated into her lesson. She also asked her students to do a mind map to reflect about what her students learned about STEM concepts at the end of her lesson.

4.1.2 The Students Had More Opportunities to Test Their Own Ideas Through the Integration of STEM Education

Before participating in the PD program, Somsak, Veera, and Somsri accepted that their students did not really have any authority in their learning. They studied the information that the teachers' provided them. They did not learn based on their interest or inquiry. Somsak reflected that he normally acted as a knowledge transfer to his students, "*I always told my students what they have to do or to learn in my class because they did not like to think. If I did not do that, they would sit still. If I did do that, they would do what I told them.*" In the case of Veera, he accepted that his students were not interested in his lessons because he focused on content knowledge. As he stated, "*Last semester, I did not let my students practice anything, and my teaching technique was not effective. My students reflected at the end that they were bored.*" Somsri encountered a similar issue. Although she let her students do activities rather than focus on content knowledge, they still participated in the activities as a passive learner. As she reflected, "*My students like cooking, so I let them do that. Most of the time, they wait for me to tell them step-by-step. They did not dare to create their own ideas and test it. This is why I need to do research on how to enhance their creative thinking.*"

After participating in the PD program, their students learned home economics via STEM-based activities. They had the opportunity to do hands-on activities. In the case of Veera, he pointed that his STEM activities let his students engaged in their own project based on their interests. His students used the engineering design process to test their ideas. As stated, *"My students did not feel bored with learning. Most of the time, they learned from creating a new style of glutinous rice balls. My students can explain the scientific knowledge that is related to it based on observation. Many groups got unexpected results, and they were curious as to how the results came about. Finally, they tried to find their own answers and improve their product."*

As Somsri reflected, "I tried to focus on students' practices and also provided them ample time to design a new dessert recipe from a sweet potato. In addition, they have to find the best way to preserve it longer. They seemed to be more interested than before because they got to test their caramel sweet potato again and again. Finally, they could tell me the best recipe to preserve sweet potato to keep it longer than usual." Similarly, in case of Somsak, he engaged his students in a competition to create a bag that can hold the heaviest weight. His students did not feel bored in his class like before. As he reflected, "My students used the engineering design process for creating a book bag. They started with identifying the problem, gathering information, selecting a method, designing and making, testing, modifying and improving, and assessing."

4.1.3 The Case Studies Asked More Probing Questions to Link Their Lessons with STEM Concepts

Initially, Somsak asked his students questions about what they learned. His students could not answer his questions and most of them kept quiet, so he frequently did not ask more questions and waited for them to ask questions based on their needs. As he reflected, *"My students could not answer my questions. They were quiet, so I did not ask them. I always let them practice according to the textbook, and if they had any questions, they would come to me to ask what they are curious about."* For Veera, he used questions in the way of summarizing the lesson to check students' understanding of the content. As he stated, *"I always asked my students at the end of the lesson what they learned today"*. In the case of Somsri, she used only yes or no questions to test students' understanding of the concepts. As she stated, *"I used only yes or no questions to check on what they learned about baking. A few of my students could answer, but most students could not."*

After participating in the PD program, all of them used more probing questions to test their students' understanding of the STEM concepts related to the home economics activities. In Veera's teaching practice, he used questions to guide his students to think about the scientific basis for why the boiled flour floats, as he stated, *"Can you tell me why we boiled flour in hot water, and why it will float?"* However, most of his students could not answer his question immediately, so he had to probe further about the change of the substance in order to make his students reflect on the change of size of flour, *"What did you observe with the difference in size between the boiled flour and the non-boiled flour?"* Finally, some students realized the change in density, so they could explain about the floating flour by applying the concept of density. As he commented, *"The size of boiled flour is bigger, so that means the volume is also bigger but the mass is stable. Therefore, the density is lower, and that makes it float."*

In the case of Somsak, he also used many questions to enhance student understanding of the STEM concepts, such as, "*What scientific concept did you use for creating your own bag? ... Could you tell me whether you used technology to create your bag? If so, tell me how you used it to create your bag? ... How did you use the engineering process when creating the bag? .... What mathematical concepts did you use in order to create your own bag?*" As a result, he reported during a group discussion, "*When I asked them about science, they knew only of experiments, so I had to ask them more about the specific STEM concepts that they used. Fortunately, some of them told me about forces. For technology, my students told me about the tools that they used to help them a create bag, such as scissors and a needle. Moreover, they were able to tell me about the engineering process, such as planning, creating, and testing their bags. For mathematics, they did not initially understand the connection very well, but they could tell me directly when they measured the weight of the book that their bag can carry.*"

In the case of Somsri, she asked her students about the caramel used for food preservation, *"Can you tell me why we add caramel to the sweet potato?"* From this question, most of her students' answered to make it sweet, but her intended answer is for food preservation, so she continued to ask them more questions, such as *"Why did we put caramel in the sweet potato?"* Finally, her students were able to tell her about how it can stop bacteria from growing, and be used as preservative agent. As reflected, *"When I asked them more, they told me about preservation, so I asked them why. They told me that it can stop bacteria from growing that can make food spoil."* However, all cases still felt the need to provide more opportunities for their students to independently think about the STEM concepts related to the home economics activities. They wanted to reduce their role as the

question provider. As Somsak stated, *"In the next lesson, I think that my students should be aware of STEM concepts related to home economics activities on their own".*

4.1.4 The Case Studies Enhanced the Application of 21st Century Skills in Their Lessons

At the beginning, all cases stated that their home economics activities are related to acquiring skills, which involved practice. However, the skills that they practiced were related to basic technical skills, such as cooking and sawing. For example, Somsak's activities focused on students' practice according to what was indicated in textbook. As he stated, *"I always asked my students to practice sawing according to the textbook, which was just practice but not really linked to daily life."* For Veera, he asked his students to practice general skills, such as how to cook according to the recipe, but he did teach them how to create new recipes. As he reflected, *"I taught them how to cook and evaluate their preparation, practice, and product, which did not evolve into a new recipe".* Similar to Somsri, she did not put much emphasis on 21st century skills. She focused on practices related to theory of baking, as she pointed out *"I always let my students practice their skills according to theory of baking. For 21st century skills, I sometimes asked my students to think by solving a problem related to cooking."*

When implementing their STEM-based lessons, Somsak intended to enhance his students' learning by integrating collaborative skills. He applied cooperative learning such as T.A.I (Team Assisted Individualization). He found that most students could work together to create their own bag and finish their tasks on time. As he stated, *"My students worked in a group while they planned, created, and tested their bag. They worked together to make their bag stronger, rather than just following what was done in the textbook.… They seemed happy to test their own ideas. However, some of the students were still absent and did not help the group. I had to find a new way to solve this problem."*

In the case of Veera, he designed his STEM-based lesson to incorporate problem-solving skills within the context of the glutinous rice balls example. His students had to identify the problem, plan a solution to solve the problem, attempt to solve the problem based on their proposed solution, and then evaluate their results. He let his students apply their ideas back and forth between design-redesign. As he stated, *"At the beginning, they did not like to think, so I had to provide them more time to think about how to make improvements when cooking glutinous rice balls in sweet coconut milk. I had to use questions to guide them to reflect on their practices that will help them to identify and solve problems, such as when they boiled glutinous rice balls that were various sizes and they were not done at the same time. They had to think about this problem and try to solve it. Finally, they could tell me that they will make them the same size. I let them do it, and their problem was solved."*

For Somsri, she designed her STEM lesson to promote her students' creative thinking. She asked her students to think about how to substitute, combine, adapt, modify, put to other uses, eliminate, or rearrange within the context of food preservation. At the end of her lesson, she found that her students applied more creative thinking, as she stated, *"I found that my students' ideas on how to preserve a sweet potato are creative because their products look different from what I have seen before, and they can apply it in real life situation."*

4.2 The Factors That Constrain or Facilitate Their STEM-Based Teaching Practices

4.2.1 Pre-Service Home Economics Teachers' STEM Knowledge

In the case of Veera, he had some experience with STEM education before participating in the PD program, but he was not confident on how to apply it in his teaching practices. As he stated, *"I tried to do a report about STEM education last year, but I thought it was too complicated for me to teach with this approach because there are too many disciplines to cover. For engineering, I had no idea what to do. I thought it was difficult."* For Somsak, he accepted that he lacked knowledge about STEM education, but he had strong intentions to integrate STEM in his teaching, as he mentioned, *"I need to develop my understanding of STEM education since I have no experience and I am not very confident with it".* Similarly, Somsri had some knowledge about STEM education before participating in the PD program, but she did not have any clear ideas on how to apply it in her lesson, as she described, *"I do not know much about STEM education, especially about science. I need to review what I learned about science before I design my lesson plans".*

After participating in the PD program, all of them were more knowledgeable about STEM education, and they were more confident with applying it in their lessons. For Somsak, he pointed that he now knew how to link home economics content with STEM education. As he reflected, *"Now, I can see the connection between home economics and STEM concepts. Home economics curriculum reflects a part of daily life that can be linked with science, technology, engineering process, and mathematics. As such, I can design my lessons on sawing with STEM education effectively. And as a result, my students benefit from this new teaching approach, something that they have not experienced before."* Veera also revealed a similar perception during a group discussion. He

stated, *"My knowledge about STEM education was increased from this PD program, and I can link my lessons with STEM education. When my students asked me about concepts that are not in my field of study, we tried to search for the information and shared our ideas."* Similarly, Somsri also felt more confident with STEM education. As she stated, *"I have more confidence with integrating STEM education into my class because I now have many learning resources about STEM education, as well as support from an advisor who is an expert in this teaching approach."*

4.2.2 Concerns Regarding the School Environment

All of the case studies had many concerns about the school environment for integrating STEM education in their lessons prior to participating in the PD program. In the case of Somsak, he revealed that STEM education was new to his school. There were only a few teachers who knew about it, so it was not the focus at his school. He stated, "*It is a challenge for me to bring STEM education into my class because my school has not focused on this teaching approach so they did not provide any support.*" Furthermore, he mentioned that there were not enough resources, "*I focused on practices rather than concepts, so I had to prepare a lot of materials in order to do STEM activities ... I used a lot of learning materials, more than usual, for my STEM activities.*" However, he got permission from his cooperative teacher to integrate STEM education in order to enhance students' sawing skills. As he stated, "*I designed learning activities that were different from what students have done. I brought STEM education into my lessons. I found that my students were actively learning and did not feel bored.*"

For Veera, his school seemed to emphasize content knowledge based on the textbook rather than student interest or real-life situations. As he stated, *"I have not seen teachers in this school let their students ask their own questions or learn through practice. They only teach students the content in the textbook"*. Veera connected his lessons on cooking glutinous rice balls in sweet coconut milk with STEM education, and then he integrated this project into other school activities in order to introduce this concept to his entire school. He said, *"My STEM lesson focused on students' creating new styles of glutinous rice balls in sweet coconut milk in order to increase the value of this dessert. In addition, I let my students sell their own dessert creations in the school fair."*

Somsri also mentioned that her laboratory room for cooking was not appropriate for doing STEM activities, and that there were not enough tools or equipment. As she stated, *"Most of the equipment in my laboratory room is broken. Sometimes, I will try to teach, but it does not work so I have to change my plans."* To cope with this problem, she spent her own money to buy materials for doing STEM activities. As she revealed after participating in the PD program, *"The cost of the material is expensive for doing these STEM activities. The school does not support these costs, so I have to buy some materials."*

4.2.3 The Students' Typically Engage in Passive Learning

All of them agreed that their students are typically passive learners. They like to learn by listening to what the teachers say in the classroom. They tried to enhance their students to be more active learners with STEM activities in home economics lesson. In the case of Veera, his students did not like thinking or writing. They appeared to prefer listening instead. As he reflected, "*When I ask my students to complete their worksheet, most of them did not complete it. When I asked them questions, they could tell me the answer that they found in the textbook, but they could not explain their thoughts."* Therefore in his STEM activities, he needed to change his students' learning style to be active instead of passive learners by getting students' to think and discuss what they learned. His students seemed to like this way of learning, as he stated, *"I think that STEM activities must be flexible, not just focused on writing, but also on discussing what they learned. I found that my students are more capable of doing activities systematically when compared to before teaching with STEM education. They also reflected in their journal entries that it would be good if they could have another chance to learn STEM education."*

Somsak had a similar experience. He revealed that his students were more familiar with being passive learners. They always waited for the teacher to tell them what they should know. As he stated, *"When I asked my students' to design their own bag, I found that they did not do anything. They were waiting for me to tell them step-by-step how to make a bag."* However, after participating in the PD program, Somsak happily revealed during group discussion that his students became more accustomed to learning through experience as a result of their participation in STEM activities, and this promoted change in their learning style. As he stated, "*My students were happy and had fun with learning when they were competing to make the bag that can carry the heaviest weight. The group that won would get extra points, so there was more classroom participation and greater application of their knowledge about various styles of sawing, such as baste and backstitch, in order to reach this goal."*

For Somsri, her students did not have much motivation for learning. Most of her students were absent during her

period, and the rest of them did not pay attention. As she stated, *"My students like to learn theory but do not like to do hands-on activities. They like to do things outside classroom, such as cheerleading and dancing. I try to encourage their interest in the lesson using various methods, but there was only me to enjoy the lesson."* However, her STEM activities seemed to be a success because her students demonstrated greater participation and more creativity during her lesson about food processing. As she said after participating in the PD program, *"My students worked together to create a new product through food processing. They used the engineering design process to test and evaluate their product. I tried to make them link their learning with science, technology, and mathematics as the basis when designing their products. Finally, their products are very creative. Some of their products could even be further developed for selling in the real market."* However, her students lost interest when the re-designing and testing process took too long. As she revealed, *"At the beginning, they enjoyed doing the activities, but they seemed to become bored if they had to re-design their products more than three times."*

4.2.4 The Limitation of Time

Before participation in the PD program, Somsak mentioned that one major limitation is the amount of time for teaching. As he stated, *"In the second semester, there are many days off of school, so there is not enough time for completing the activities. I have to teach a lot of content in a short period of time, so I would often assign homework instead"*. After participating in the PD program, he pointed this out again, *"Normally, I teach one period per week. I spent my time teaching STEM education more than usual"*.

For Veera, the limitation of time was apparent one week after implementation of his STEM-based lessons. As he reflected about managing time, *"I was not good in managing my time for teaching. There are many activities in a STEM lesson. Sometimes, I was hurrying to finish an activity on time, but my students did not understand. In some lessons, I spent more time than I planned to."* He often coped with this problem by asking his students to do activities before attending his class. As stated, *"Some activities take too much time in the class period, so I asked my students to prepare or to do something before coming to my class. It saved class time to discuss their questions and what they learned."*

In the case of Somsri, her STEM lesson was in an elective subject, so she has flexibility when designing her lesson plans. As she stated, *"It is flexible for me to design my lesson in my food preservation course because it is an elective course."* However, as she pointed out, "*I can tell that there are many unexpected activities in my school. In doing so, there is not enough time for doing STEM activities"*. To cope with this problem, she asked her students to do some activities before class. As stated, *"Because of the limitation of time, I asked my students to work in group outside classroom."*

5. Conclusion and Discussion

As a result of participating in the PD program, all three cases changed their current teaching practices in order to integrate STEM education. All of them attempted to incorporate STEM education in a way that motivates student ownership of learning by providing more opportunities for students to generate and test their own ideas within a home economics framework. Consistent with this, Wesley (2015) pointed out that home economics and STEM education share similarities as an integrated and practical discipline, focused on studying family and life. Home Economics educators can incorporate real world lessons and problems, immerse students in hands-on inquiry and open-ended exploration, and involve students in productive teamwork, which are guided by the engineering process, integrate content from both math and science courses, and allow for failure. Furthermore, as demonstrated by these three cases, they can link their activities with 21st century skills, which is in line with the *"Thailand 4.0"* policy (Baxter, 2017).

With respect to factors that constrain or facilitate their STEM teaching practices, there were four factors that emerged from this study. First, pre-service home economics teachers' lacked STEM knowledge due to the fact that there are very few general guidelines or examples available for home economics teachers to integrate STEM approaches in their classrooms. The findings from this study confirmed findings from Lederman & Lederman (2013), which reported that many pre-service teacher training programs do not incorporate STEM training, and STEM concepts are often ambiguous to pre-service teachers. The three cases' in this study had limited knowledge about STEM education, which affected their ability to design STEM-based home economics lessons. Second, students are often in the habit of being passive learners. Based on these case studies, their students would initially participate as passive learners. They transitioned to active learners as they became more engaged with the project-based STEM activities. Consistent with this, Boonruang (2015) pointed out that STEM education should include the opportunity to solve problems in daily life, as well as challenge them to seek alternative solutions. Third, all three cases described the school environment as not being conducive for STEM

education. As previously reported by Nontaso and Thipchart (2018), some schools do not have adequate STEM learning equipment or budget to support STEM teaching. Lastly, although these three cases felt that their pedagogy was developed after participating in the PD program, they still found that they needed more classroom time to effectively apply STEM into their lessons. Similarly, Srikoom (2018) also found that most teachers who integrate STEM education into their teaching practices feel limited due to time constraints.

6. Recommendations

The changes observed with the three cases in this study provide supporting evidence that the activities developed and implemented in this PD program do indeed help to prepare home economics teachers with integrating STEM content into their teaching practices. The findings from this research suggest that in order to effectively integrate STEM education into home economics lessons, several factors need to be considered, including STEM knowledge, school context, students' learning style, and time constraints. However, more research is needed to demonstrate the effectiveness of the PD program on a larger scale. For the continual development of STEM teaching in home economics, there should be professional learning communities available to provide pre-service and in-service teachers guidance with their STEM-based teaching practices. In a future study, the researchers need to continue to follow-up on the participants in this PD program to ultimately assess the impact of their STEM lesson in home economics on student learning outcomes.

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