

STEM Collaborative Teacher Professional Development
: Preschool Teachers' Understanding and Teaching Practices
โปรแกรมการพัฒนาวิชาชีพครูแบบร่วมมือเรื่อง STEM
: ความเข้าใจและการจัดประสบการณ์การเรียนรู้ของครูปฐมวัย

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บทคัดย่อ

การวิจัยเชิงคุณภาพนี้มีวัตถุประสงค์เพื่อ 1) ศึกษาความเข้าใจและการจัดประสบการณ์การเรียนรู้แบบสะเต็มของครูปฐมวัยโดยใช้โปรแกรมการพัฒนาวิชาชีพครูแบบร่วมมือเรื่องสะเต็มศึกษาสำหรับครูปฐมวัย ซึ่งโปรแกรมการพัฒนาวิชาชีพครูแบบร่วมมือเรื่องสะเต็มศึกษาสำหรับครูปฐมวัยแบ่งออกเป็น 2 ขั้นตอน ได้แก่ 1) การอบรมเชิงปฏิบัติการใช้ระยะเวลา 36 ชั่วโมง และ 2) การจัดประสบการณ์การเรียนรู้แบบสะเต็มศึกษาในห้องเรียนที่อาศัยความร่วมมือระหว่างครูและผู้วิจัย กลุ่มศึกษา ได้แก่ ครูปฐมวัยที่สอนเด็กในช่วงอายุระหว่าง 5-6ขวบ เป็นครูปฐมวัยในสังกัดโรงเรียนรัฐบาล และเอกชน จำนวน 14 คน เครื่องมือที่ใช้ในการวิจัย ได้แก่ แบบสัมภาษณ์ แบบสังเกตการสอน การบันทึกวิดีโอ การสอน แผนการจัดประสบการณ์การเรียนรู้ STEM และแบบสะท้อนความคิด วิเคราะห์ข้อมูลโดยใช้การวิเคราะห์แบบอุปนัย

ผลการวิจัยปรากฏว่าครูมีความเข้าใจเรื่องสะเต็มศึกษามากขึ้นหลังจากเข้าร่วมโปรแกรมการพัฒนาวิชาชีพครูแบบร่วมมือเรื่องสะเต็มศึกษา ครูมีความเข้าใจว่าแนวทางการเรียนรู้ตามแนวทางสะเต็มศึกษานั้นการเรียนรู้แบบแก้ปัญหา การเรียนรู้แบบการสืบเสาะหาความรู้และการเรียนรู้แบบโครงการ กิจกรรมที่จัดตามแนวทางสะเต็มศึกษา ส่งเสริมให้เด็กได้คิดแก้ปัญหาและคิดอย่างมีวิจารณญาณ การออกแบบและการปฏิบัติการสอนตามแนวทางสะเต็มศึกษาของครู ปรากฏว่า ครูสามารถจัดให้สอดคล้องกับบริบทโรงเรียนได้ โดยสอดคล้องกับหน่วยการเรียนรู้เดิมของโรงเรียน โดยใช้ร่วมกับแนวคิด Big ideas เพื่อระบุแนวคิดสำคัญของแต่ละวิชาให้ชัดเจนในหน่วยการเรียนรู้ และเชื่อมโยงกับแนวคิดทางวิทยาศาสตร์ คณิตศาสตร์ เทคโนโลยี และวิศวกรรมศาสตร์ ครูมีมุมมองว่าแนวคิดเทคโนโลยี และวิศวกรรมศาสตร์เป็นเรื่องที่ทำหายและยากที่สุดในการบูรณาการเข้ากับหน่วยการเรียนรู้ในระดับปฐมวัยโดยการบูรณาการวิศวกรรมศาสตร์ในระดับปฐมวัย ครูใช้นิทานหรือเรื่องราวสมมติในการสร้างปัญหาหรือสถานการณ์สมมติ ในการออกแบบทางวิศวกรรมสำหรับเด็กปฐมวัยมีลักษณะเป็นแบบจำลอง (โมเดล) ไม่เน้นการใช้งานได้ในชีวิตจริง สำหรับเด็กในวัยนี้ การออกแบบทางวิศวกรรมจึงเน้นที่การเลือกใช้วัสดุอุปกรณ์ที่เหมาะสม นอกจากนี้การจัดสภาพแวดล้อมและบรรยากาศในห้องเรียนสามารถส่งเสริมการเรียนรู้ STEM สำหรับเด็กปฐมวัยได้

คำสำคัญ: ความเข้าใจสะเต็ม ศึกษา ครูปฐมวัย โปรแกรมการพัฒนาวิชาชีพครูแบบร่วมมือเรื่องสะเต็ม

Abstract

The purpose of this qualitative research was to study preschool teachers' understanding and practices on STEM education after participating in the STEM collaborative teacher professional development (STEM CPD). The program consisted of 2 steps which were 1) the 36 hour workshop training program, and 2) the implementing STEM lesson plan into classroom practices with the collaboration among teachers and researchers. The research participants were 14 preschool teachers whom taught 5-6 year-olds in public and private schools. The data were collected from interview, observation, video recording, STEM lesson plans, and reflective notes. The data were analyzed using analytic induction.

The findings of this study indicated that teachers gained a better understanding on STEM education after participating in the STEM CPD. They understood that learning approach of STEM focused on problem solving, inquiry, and project-based learning. The activities based on STEM education encouraged children to problem-solve and think critically. In teaching practices, teachers incorporated STEM concepts into school theme units by using the concept of big ideas to create a conceptual framework for each theme and to connect main concepts of science, mathematics, technology and engineering. Engineering and technology were the hardest disciplines in teachers' perspective to integrate in these cases. To incorporate engineering appropriately for preschool children, teachers used both stories and real or mock situations to create problems or situations in which required children to design and construct a structure to solve the given problems or situations. Interestingly, the engineering designs of young children tend to be models, not functional or could be used in real life. For children at this age, engineering designs focused more on choosing appropriate materials. Also, the classroom setting and environment could encourage STEM learning for young children.

Keywords: *Understanding of STEM, Education, preschool teachers, STEM collaborative teacher professional development*

Introduction

In recent years, Thailand has strived to improve the quality of education to prepare children to have necessary 21st Century skills and to meet the challenges of the rapid changing world (Office of the Education Council, 2016). STEM education has become to the focus of attention since it is seen as a key that develop important 21st century skills such as critical thinking, problem solving, creativity, innovations skills, curiosity, and collaboration (National Research Council, 2011). STEM education is an integration of contents and skills of at least two STEM subjects which are Science, Technology, Engineering, and Mathematics within classroom activities. Thus, the learners can implement knowledge of every disciplines in problem-solving, and developing many innovations (Moomaw, 2013). STEM

education can begin in early years since children engage with their environment and the world around them in ways that promote learning related to science, technology, engineering, and math from their earliest years. Teaching STEM in the early years can provide strong foundational STEM skills for children in which increases probabilities of their future success. Two main goals to teach STEM for young children are to support them to like science and to instill the love of learning (National Association for the Education of Young Children, n.d.).

Although educators are aware of the importance of STEM education, neither educators nor researchers consistently agree or understand what STEM education should really be in K-12 education. This disagreement makes it difficult for K-12 teachers to grasp the STEM concept and more confusing on how to teach using STEM integration approaches in their classroom (Brown, Brown, Reardon & Merrill, 2011). In Thailand, one of the challenge of STEM education, particularly in preschool is that there are a few general guidelines or models for teachers to follow regarding how to teach using STEM integration approaches in classrooms. Thus, more research need to be done to look at teachers' understandings and implementation of STEM integration.

Considering the nature of STEM education, the teaching strategies should integrate real-world situation, so it can be merged easily into learning experiences of young children. The development of preschool teachers to understand and implement the STEM education in their classroom efficiency is important. Unfortunately, in Thailand, professional development for preschool teachers on STEM Education as well as researches in this area are limited. Moreover, science learning experiences for preschool have not been widely promoted as well as teaching science in preschool students often focuses on teaching facts and information. Technology, engineering teaching and learning also are unfamiliar for preschool teachers. In order to help preschool teachers to understand STEM Education and provide STEM learning experiences for children, a profession development on STEM Education is necessary.

To provide STEM learning experience, teachers need to be prepared to engage children's STEM learning. They are expected to provide learning opportunities to extend children's understanding in science and mathematics and to help children learn to use technology as learning tool and make connections to engineering. So, they can use and apply their knowledge to new situations (Moomaw, 2013). Yet, applying STEM education in the classroom for preschool teachers can be quite difficult since the teachers do not have any training they need to support children's learning (Brenneman, Stevenson-Boyd, & Frede, 2009; Whitebook & Ryan, 2011).

According to literature on professional development, collaborative teacher professional development is appropriate for teachers to learn new things such as curriculum teaching and learning approach (Gulamhussein, 2013). Professional development that on-going and collaborative development within the context of the school is necessary for significant change to occur in teachers'

practice (Sturko & Gregson, 2009). Collaborative teacher professional development is a kind of professional development that support on-going and collaborative development within the context of the school and this type of the professional development can promote a significant change in teachers' practice (Sturko & Gregson 2009). Thus, this study explores the impact of STEM collaborative teacher professional development (STEM CPD) on preschool teachers' understanding and practices.

Research Questions

The research questions that guide this study are as follows:

- 1) What are preschool teachers' understanding of STEM education after participating in STEM CPD?
- 2) How are the STEM teaching practice in classrooms?

STEM in Preschool

The four disciplines of STEM could be taught in preschools using the following approaches (Boston Children's Museum, 2011):

1) Science in preschool deals with scientific concepts as children experience natural wonders in their life and environment. Scientific activities involve observing, perceiving, engaging, and exploring in nature.

2) Preschool technology means the technological process and the use of tools such as rulers, scissors, tape, glue, or sometimes in the form of easy-to-assemble devices in toys, such as wheels that correspond to the way of engineering design. In addition, searching, studying, and recording somethings using a computer or a smartphone is part of technology.

3) Engineering in preschool means a design process based on preschool scientific and mathematical knowledge, including building blocks (Christenson & James, 2015) or using LEGO to design and create structures.

4) Preschool mathematics focused on mathematical experiences that incorporate contents in number and operations, geometry, algebraic reasoning, and measurement (National Council of Teachers of Mathematics, 2017). The mathematic experience should focus on both mathematics and the development of young children, thus the complexity of the content depends on the level of development, both physically and intellectually according to children age.

Characteristics of STEM integrated preschool experience. It has the following key features:

1) STEM links into development to strengthen intelligence. STEM learning for enhancing intelligence is to learn about causes and effects, assumptions, predictions, and theories. This learning is the nature of early childhood learning, which corresponds to scientific inquiry. Providing a STEM learning experience for students should learn through important aspects of scientific inquiry, including

observation, questioning, exploration and explanation, but the level of inquiry can be adapted to the suitability of the teaching style and the age of the learner. In addition, the integration of preschool science should also take into account three main components of science: scientific skills and processes, scientific knowledge, and scientific attitudes.

2) Designing activities using technology processes. Preschool teachers should consider the potential and level of competence of learners and may have to adjust the procedures. For example, in the process of gathering information to find solutions, teachers can integrate concepts or knowledge they need to learn or apply to encourage learners to connect with knowledge. The lessons learned in one context can be applied to problem solving. In addition, teachers should aim to promote the development of children's imagination and creativity during activities, and should promote the use of technology products, especially those of everyday life, in a safe manner.

3) The stage of engineering design, children may not be able to sketch or write their own sequence of steps. Teachers may use children's drawing to guide children. In addition, they should also talk to children to help them articulate their ideas as well as give assistance with some procedures when needed. When children complete their work, teachers should help them evaluate their work.

The STEM collaborative teacher professional development

The STEM collaborative teacher professional development (STEM CPD) is based on constructivist theory and social constructivist theory. The STEM CPD could be used to promote preschool teachers to understand STEM education, and facilitate in developing teaching practice in classroom.

The STEM CPD consisted of 2 steps which were (1) the 36 hour workshop training program, and (2) the implementing STEM lesson plan into classroom with the collaboration among teachers and researchers. The literature review and focus group suggested that Thai preschool teachers had inadequate knowledge about science teaching and integrated approach so in the workshop, 6 days total 36 hours, includes 3 main contents namely teaching and learning 4 disciplines, integrated approach in preschool, and STEM education.

In STEM CPD, teachers received guidance and assistance in the planning and implementation of learning. Also, it encouraged teachers to create a supportive learning atmosphere and a network of cooperation in school and out of school.

Method

The research participants were 14 female preschool teachers from 4 schools, which were two private schools and two public schools in Bangkok Metropolitan Region. We recruited participants in this purposive sample using these criteria: 1) never use STEM integration in teaching 2) had a personal

interest in professional development, and 3) willingly and able to participate in every step of the research.

Qualitative research methods using multi-case studies facilitated exploration of a phenomenon within its context using various data resources. It ensures that the issue is seen through multiple lens which let many facets of the phenomenon to be understood (Baxter & Jack, 2008). The researchers, therefore, selected this design to gain an insight on preschool teachers' understanding and classroom teaching practice on STEM Education.

Procedure and data collection

Before STEM CPD, preschool teachers were interviewed about STEM education. The interview focused on (1) meaning of STEM education, (2) appropriate goals and objectives for integrated STEM in preschool, (3) teaching and learning of STEM in preschool, and (4) designing STEM lesson plan.

After completing the workshop in this training program, the researchers observed all of the participants in their classrooms to gather data on classroom setting, classroom environment, teaching practice, and students' learning behaviors. When finishing with the classroom observations, we set up time to meet with the teachers to explain the process of developing STEM lesson plans. In the second step of STEM CPD, the teachers from each school work collaboratively to develop STEM lessons by integrating 4 STEM subjects into learning units that the team selected. Subsequently, we conducted a formal meeting to meet with the teachers from each school and used online social media to exchange ideas, make suggestions, and provide feedbacks on the STEM lesson plans that each school developed. The teachers then modified the lesson plan. After that each school selected one teacher from the team to teach using the modified STEM lesson plans. During the teaching, we and the rest of the teachers in the team observed the STEM teaching lesson, classroom setting, classroom environment, and students' learning behaviors using the participant observation.

For each STEM lesson, we observed at least two days and we recorded every lesson using video cameras. After finishing with each lesson, all of the teachers in the team were asked to reflect on the teaching experience as well as give feedbacks to their peer on the lesson. Each meeting session was documented and audio-recorded. Finally, we conducted the closing meeting with all the teachers to exchange their STEM teaching experiences, the conversations and presentation during this meeting were documented and audio-recorded. After that, teachers were interviewed about STEM education again.

Data Analysis

The analysis began with sorting and organizing data from interview records, observational records, STEM lesson plans, video records, and teaching reflective forms. Then, all data were carefully and thoroughly read and examined both individually and cross-comparison to give codes. Then, the codes were categorized into categories. These categories were analyzed to find patterns and themes.

To verify data, the researchers used the concept of prolonged engagement, and spent great amount of time in the field during the process of implementing of both steps of the STEM CPD to gain an in-depth understanding of teachers' classroom practice as well as working conditions and attitudes about teaching practice and work. Triangulation in multiple data, investigators, and methodological process were also used to verify the data.

Findings

The findings of this study were reported into two parts.

1. Preschool teachers understanding about STEM education

Analysis of the data revealed themes of preschool teachers' understanding on STEM education before and after STEM CPD. The result showed that teachers gained a better understand about STEM education after participated STEM CPD. They had more clear understanding of STEM education in the context of preschool education. They understood the specificities in term of concept and process of each subject of STEM. Additionally, they had understanding of the goals of preschool STEM teaching and learning.

Items	Before CPD	After CPD
Meaning of STEM education	The integration of four subjects namely science, technology, engineering and mathematics.	The integration ideas and processes of two or more of the STEM subject areas associated with real world experiences as student had opportunity to apply their knowledge.
Appropriate goals and objectives for integrated STEM in preschool	Learning content and processes of all four subjects.	In early childhood, STEM objectives are to encourage and motivate children to learn, to be active, to critical thinking, to inquiry learning and to take initiative in their own learning.
Teaching and learning of STEM in preschool	The integration of STEM in preschool curriculum includes: 1) to insert four subjects in six core activities of the day: or 2) to set STEM activity separate from six core activities of the day.	Teaching and learning approaches of STEM in preschool include problem-based learning, inquiry-based learning, and project-based learning.
Science idea and process	Science learning for children is to experiment, and observe.	Teachers will be able to understand both scientific concepts and the scientific process

Items	Before CPD	After CPD
		such as inquiry, observation, and compare data.
Technology idea and process	Technologies for early childhood is the use of technologies such as electronic devices and facilities tools.	The benefits of using technology to learn and the way of life.
Engineering idea and process	Creative art and imagination.	Engineering design concept is based on work conditions, material selection, and presentation and testing.
Mathematics idea and process	Numbers, counting, shapes, shape, size, relationship.	The concept of mathematics are operations, measurement, geometry, shape, size and mathematical processes.
Designing STEM lesson plan	-	The designing STEM activities will reflect the full context of the school by incorporating into units which are identifying key concepts of each subjects.

2 Preschool teachers teaching practice in STEM

The results of preschool teachers teaching practice in STEM were reported into two parts.

2.1 Characteristics of STEM themes in preschool classroom

1) Though integrating STEM into learning units and creating STEM conceptual framework and main questions for inquiry using big idea concept, teachers had a better understanding of interconnection of each subject and were able to integrate concepts of science, mathematics, technology and engineering into lesson plans easier.

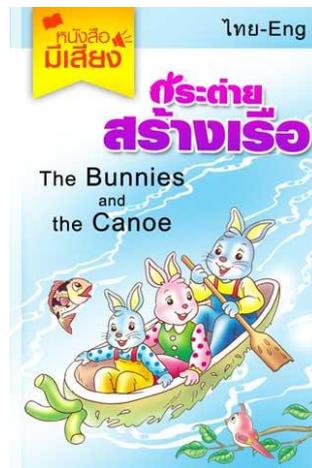
Example: Big idea of the transportation unit

Big Idea: Traveling on land: cars	
Question: Science - How can a car move? - How many ways of transportation? - What land-vehicle can move the fastest? - What are the components of a car?	Question: Technology - If there is no car, how would the trip be? - If there is no car, what other ways we can use to travel on land?
Question: Engineering - What devices will children use to design their vehicles as fast as possible?	Question: Mathematics - What shape is the shape of a car? - How many wheels are there? - Why does the wheel must be in circular shape?

	<ul style="list-style-type: none">- What would it happen to a car, if the wheels were not in circular shape?- Comparing three ways of transportation, which way is the fastest way and which is the slowest?
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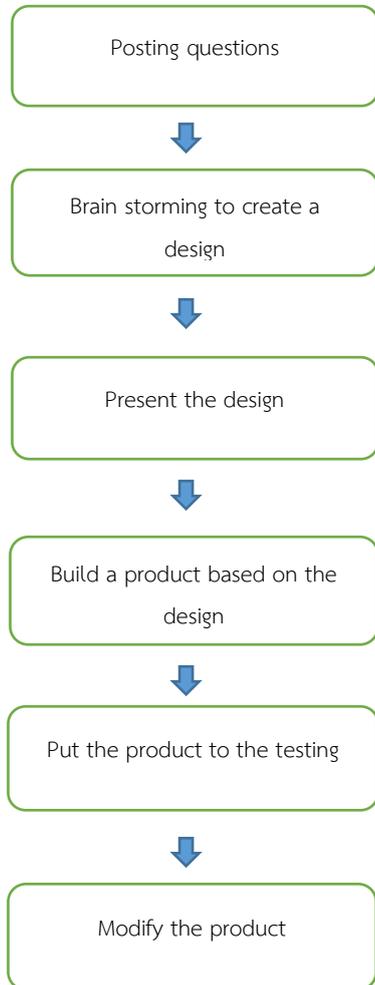
2) Teachers incorporate engineering discipline by using a situation that occurred in a storybook, a song, as well as a pretend situation to create a problem or circumstance, in which required children to design and construct a product to solve the given problem or situation.

Example:

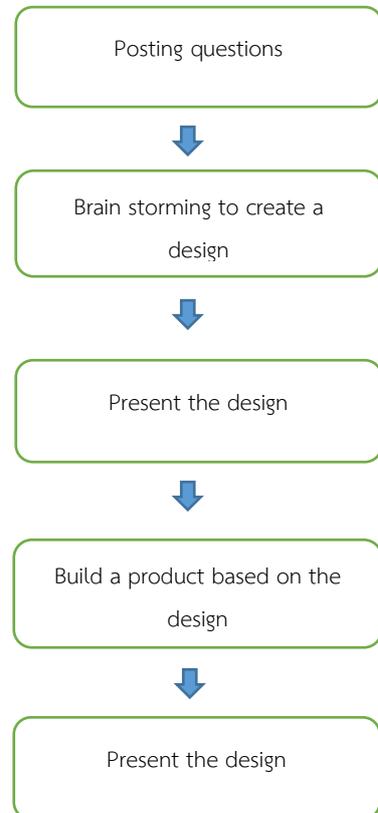


3) To integrate engineering discipline, teachers engaged children in creating a product to solve the problem. In this activity, teachers might or might not set up conditions for the product. If the teachers set up the conditions, the final products would be put to testing. There two model of engineering design process in this study.

1) Model 1



2) Model2



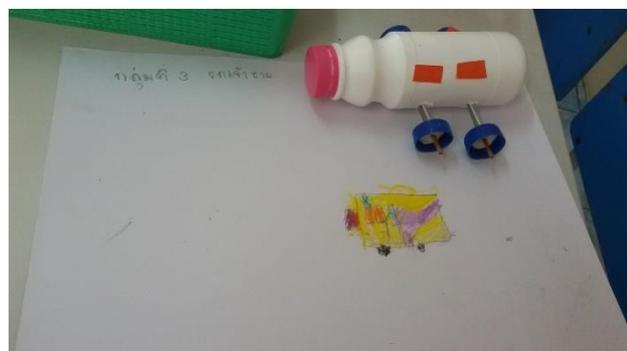
Brain storming to create a design.



Present the design



Build a product based on the design



Picture: Steps in engineering process

4) The influential factors that determined designing and selecting appropriate materials successfully to create a product were learning experiences that involved in mathematics and scientific thinking through inquiry activities and using information about technology that related to a given problem or situation.

2.2 Classroom setting and environment and teaching behaviors of teachers

1) Classroom setting and environment could stimulate STEM learning of young children. Also, using real objects as learning materials and using technology can support the learning as well.

2) Teachers who used questions effectively can promote STEM learning, whether the questions were planned ahead before teaching and asked during teaching.

Discussion and conclusion

The results of this study indicated that teachers gained a better understanding on STEM education after participating in the collaborative teacher professional development. However, it was found that teachers understood STEM education better and able to implement STEM in their traditional lesson plan successfully, not during the participating in the workshops, but during the collaboration among teachers and researchers. It was notable that collaboration, support and feedbacks during the design of STEM learning linked what the teachers had learned from the workshop and the teaching practices in the classroom. As a result, they gained a better understanding about STEM Education.

In practice, for preschool teachers, the most challenge task in STEM teaching was to incorporate disciplines of engineer and technology. To develop STEM themes, teachers selected the learning units that they thought were possible to merge engineer design process. This helped them to gain more confident and lead to successful in teaching via STEM themes.

The engineering design process according to STEM education focused on applying knowledge in STEM discipline to solve real world problems. Yet, it was evident in this research that the engineering designs of young children could answer the given conditions, but functioned more like models and could not be used to solve problems in real-life. For young children, the researchers suggested that the engineering design process did not necessary have to solve real-life problems. It could just focus on choosing suitable materials and creating models that serve the purposes.

Although the teachers taught with a different learning unit each week, they did not change learning centers or add new materials to the learning centers in keeping with the new learning unit. Also, real objects were often introduced to children as learning materials only during circle time activities but not in the learning centers. However, when teaching with STEM themes, teachers reported that they used learning resources outside the classrooms more and arranged classroom setting and environment in accordance with STEM themes. STEM themes not only promoted STEM learning

experiences, but provided opportunities for children to learn from the environment as well as through other learning activities in classrooms.

Another important aspect that ensured teachers in teaching STEM was the collaboration among teachers and the researchers. Through planning STEM lessons, exchanging ideas and receiving feedback, teachers gained a better understanding and be able to improve their STEM lessons. Also, the teaching team, that were familiar with working together cooperatively, showed more strength in teamwork and some of the teachers in the team were comfortably take on a leadership role leading other teachers to work together. These features facilitated the teachers in develop STEM themes effectively.

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