Examine pre-service science teachers’ existing ideas about STEM education in school setting

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Abstract. Thailand Office of Basic Education Commission (OBEC) has pushed in-service teachers to develop his or her competence of organizing STEM education instruction. Another solution of increasing STEM in-service teacher is provide pre-service science teachers to generate their ideas of organizing learning activities and carried out research about STEM education during their teaching practice. This study aimed to examine pre-service science teachers’ conceptions of STEM education. The participants included 10 pre-service science teachers who enrolled school internship course of Khon Kaen University for teaching practice in schools. These participants will be supervised by the author. On the way of supervising, participants have meeting to generate the ideas of STEM education learning activities and research about STEM education on Friday afternoon for every week. Methodology regarded interpretive paradigm. Pre-service teachers’ conceptions of STEM education will be interpreted participant observation, interview, STEM education lesson plan, teaching performance, and other tasks. Data collection was carried out for 4 months. The data will be interpreted to examine the categories of pre-service teachers’ conceptions of STEM education. The findings will clarify what their perception on STEM education, and what and how they generate ideas for developing lesson plan; to integrate science, mathematics, and others for practicing in context; and to provide engineering practices and engineering design of technologies as the context. Their ideas of research about STEM education also reflect what they emphasize to develop students’ 21st century skills, and provide instruction requiring the context of problem solving in the real world or task through teamwork. The paper may have implication for developing pre-service STEM teachers.

Keywords: STEM education, pre-service teachers, conception

1. Introduction
With the current focus on teaching in the science, technology, engineering, and mathematics (STEM) areas, it seems that Thailand STEM education was influenced by the USA STEM education. The USA national standards in science and mathematics are good examples of the need for the integrating technology in mathematics and science teaching. The USA next generations science standards [6] have supported the integrative and interdisciplinary perspectives in teaching and learning in science. This framework is organized through three dimensions: (a) practices that scientists and engineers use as they investigate models and theories; (b) crosscutting concepts, such as patterns and cause and effect, which are ways of linking different domains of science; and (c) core ideas that refer to how science content has been organized. Mathematics education in the USA also has presented a new set of learning standards that promote practices that reflect not only topics that mathematics as a discipline supports but also how students access and apply such topics. The USA National Council of Teachers...
of Mathematics’ process standards emphasize problem solving, reasoning and proof, communication, representation, and connections as foundational in student learning. The standards also address strands of mathematical proficiency: adaptive reasoning, strategic competence, conceptual understanding, procedural fluency, and productive disposition [5], [10]. As a whole, this approach envisions mathematics teaching and learning as a student-centered and problem solving–based approach enacted through active communication among students and teachers. The International Society for Technology Education standards and practices also call for students to be critical thinkers, problem solvers, and good decision makers and emphasize engaging students in collaborating and communicating their understandings [3].

In order to suggest teachers to develop STEM education learning activities, the curriculum may provide learning content standard to focusing more on knowledge practicing [7], provided good example of content standard for Grades 3–8: Integrating Science, Technology, Engineering, and Mathematics. They provided Mathematical, scientific, and technological practices. Mathematical practices included (1) Make sense of problems and persevere in solving them, (2) Reason abstractly and quantitatively, (3) Construct viable arguments and critique the reasoning of others, (4) Model with mathematics, (5) Use appropriate tools strategically, (6) Attend to precision, (7) Look for and make use of structure, and (8) Look for and express regularity in repeated reasoning.

Scientific practices included (1) Ask questions and define problems, (2) Develop and use models, (3) Plan and carry out investigations, (4) Analyze and interpret data, (5) Use mathematics and computational thinking, (6) Construct explanations and design solutions, (7) Engage in argument from evidence, and (8) Observe, evaluate, and communicate information. Technology practices included (1) Become aware of the web of technological systems on which society depends, (2) Learn how to use new technologies as they become available, (3) Recognize the role that technology plays in the advancement of science and engineering, and (4) Make informed decisions about technology, given its relationship to society and the environment.

STEM education in Thailand has been strongly driven. Thailand Office of Basic Education Commission (OBEC) has pushed in-service teachers to develop his or her competence of organizing STEM education instruction. The author as the lecturer in a university think that another solution of increasing STEM in-service teacher is provide pre-service science teachers to generate their ideas of organizing learning activities and carried out research about STEM education during their teaching practice. The Khon Kaen University pre-service teachers could be enhanced to develop conceptions of STEM education in school setting when they enrolled the subject of school internship for teaching practice in school. This study aims to examine pre-service teachers’ conception about STEM education when they enrolled in the subject of school internship. This course will support and build up community of practice for pre-service teachers to develop ideas of STEM education learning activities for teaching in their teaching practice schools [8], [9], [11], [12].

What the conceptions of STEM education should be provided for teachers? It found that descriptions of what comprises STEM content and practices and what STEM conceptions look like range in the literature, especially conceptions of STEM education [1]. However, there are three consensus issues of discussion about STEM education including (a) instructionally (b) as a set of integrated or interconnected disciplines, or (c) as more dependent on the stakeholders or context in which it is viewed or conceptualized. For this study, we will hold [4] definition of STEM education for enhancing teachers. They define it as “the teaching and learning of the content and practices of disciplinary knowledge which include science and/or mathematics through the integration of the practices of engineering and engineering design of relevant technologies.” To them, five characteristics distinguish integrated STEM instruction from other teacher pedagogy: (a) the content and practices of one or more anchor science and mathematics disciplines define some of the primary learning goals; (b) the integrator is the engineering practices and engineering design of technologies as the context; (c) the engineering design or engineering practices related to relevant technologies requires the use of scientific and mathematical concepts through design justification; (d) the development of 21st century skills is emphasized; and (e) the context of instruction requires solving a real-world problem or task through teamwork. This conceptualization of STEM is grounded in learning research.
2. Methodology
Methodology regarded interpretive paradigm. This study aimed to examine pre-service science teachers’ conceptions of STEM education. Pre-service teachers’ conceptions of STEM education will be interpreted participant observation, interview, their developing STEM education lesson plan, teaching performance, and other tasks.

3. Participants
The participants included 10 pre-service science teachers who enrolled school internship course of Khon Kaen University for teaching practice in schools. These participants will be supervised by the author.

4. Method of inquiry
The 10 pre-service science teachers who enrolled school internship course of Khon Kaen University for teaching practice in schools were supervised by the author. On the way of supervising, participants have meeting to generate the ideas of STEM education learning activities and research about STEM education on Friday afternoon for every week. The invention on Friday afternoon included share vision of STEM education, teaching approach of STEM education in context, generating ideas for STEM education lesson plan, reflection for further ideas of developing STEM education lesson plan, and research paradigm and methodology.

The share vision of STEM education, the participants were asked to reflect on what they agreement on STEM education as the following questions: (1) What is your perception about the significances of STEM education? (2) What is your learn about STEM education? (3) What did you about teaching strategies for STEM education? (4) Based on Thailand educational situations, could all Thai school teach STEM education in schools? and (5) For you, is it possible to organize STEM education in schools? why?

STEM Education Teaching approach as inquiry from the context based was introduced to the participants. The STEM education as inquiry from the context based consists of 7 stages. These include (1) Identification of social issues, (2) Identification of potential solution, (3) Need for knowledge, (4) Decision-making, (5) Development of prototype or product, (6) Test and evaluate the Solution, and (7) Socialization and completion decision stage.

The intervention was carried out for 4 months. Pre-service teachers’ conceptions of STEM education will be interpreted participant observation, interview, their developing STEM education lesson plan, teaching performance, and other tasks. The interpretation will examine the categories in order to construct meaning of pre-service teachers’ conceptions of STEM education.

5. Findings
The findings will clarify what their perception on STEM education, and what and how they generate ideas for developing lesson plan; to integrate science, mathematics, and others for practicing in context; and to provide engineering practices and engineering design of technologies as the context. Their ideas of research about STEM education also reflect what they emphasize to develop students’ 21st century skills, and provide instruction requiring the context of problem solving in the real world or task through teamwork.

**Pre-service teachers’ perception on STEM education**
The share vision of STEM education, the participants were asked to reflect on what they agreement on STEM education. All pre-service teachers held positive conception of STEM education. They perceived that the STEM education is the integration among science, technology, engineering, and mathematics for school teaching and learning when they were asked to explain the significances of STEM education. Some of them mentioned that the STEM education related to the STS teaching. Examples of pre-service teachers’ explanation are below:

- **STEM education is the integration among 4 disciplines in teaching for supporting students to design innovations or find some solutions.**
- **STEM education is the integration of knowledge for surviving the global workforce and good citizen in the 21st century.**
STEM education was developed from the STS theory. The engineering was added to linking science and mathematics together.

All pre-service teachers held the good concept of teaching for the STEM education. They mentioned about teaching strategies which could support STEM education when they were asked to explain what they learn about STEM education. They considered the issues of integrated engineering as solving problems through engineering process design. Examples of pre-service teachers’ explanation are below:

\textbf{STEM education is not teaching strategies or pedagogy. It is the framework to inform how to link the science, technology, engineering and mathematics together. Many teaching strategies could be applied for STEM education such as STS approach, 5Es, POE, PBL and so on.}

\textbf{STEM education is about teaching science and mathematics through the engineering design process}

\textbf{STEM education teaching and learning is the problem based learning. The problem should be provided based on the social issues. The technology could be applied on the way of solving problem through EPD.}

This indicated that the participants held good conception of STEM education. They understood the teaching strategies to provide the learning activities of STEM education. Some of them are aware of the distinguish of technology and engineering, and how the integrated should be made among STEM.

\textbf{Pre-service teachers’ generating ideas for developing STEM education lesson plan}

Pre-service teachers could generate ideas for developing STEM education lesson plan. The evidence of their generating ideas could explain when they identify social issues, designing worksheets for identifying possible solution, providing science learning activities, expectation of the learners’ possible prototype or product, the strategies of enhancing students to develop framework of testing the prototype, and providing the ideas of enhancing students to present their prototype.

(1) Ideas of identifying social issues

Nine of ten pre-service teachers could explain their social issues which could allow students to inquiry science, mathematics and other knowledge. And, these issues could set up the problems related to context of science, mathematics, and technology in society. These issues included making a spinner, designing water park, creative packaging, sound pollution, and so on.

(2) Designing worksheets for identifying possible solution

The worksheets for identifying possible solution were designed when they discussed how to enhance students’ critical thinking about the capitals related to social issues. One of pre-service teacher proposed that we need to remind students the meaning of five capitals, and then ask students to mention the related capitals. Therefore, the worksheets consists of three columns; the first provide the social issues, the second provide the meaning of each five capitals, then, the third provide the space to put students’ ideas about five capitals on.

(3) Providing science learning activities

The authors reflected the pre-service teachers to provide the experiments or other inquiry activities regarding on constructivist view of learning. Mr. Jay pre-service teachers showed the good examples of how to provide questions to enhance students to share their ideas for designing rotation motion experiment. Mr. Jay asked many questions with aiming to put students’ answer together for building up the strategies of doing experiments. So, not only constructivist view of learning was reminded but also the nature of science.

(4) Expectation of the learners’ possible prototype or product

Pre-service teachers were asked to provide the expectation of the learners’ possible prototypes or products for their solutions. This scaffolding allowed pre-service teachers to consider about students’ knowledge and how pre-service teachers’ understanding of applying integrated knowledge of science, mathematics, technology and engineering. For example, Tanya pre-service teacher expected that students would design various curve and slope sliders. This designing may give students chance to make sense the friction force and motion depends on various curve and slope. On
the way of designing, she expected that students could apply also other knowledge for making the fantastic sliders.

(5) The strategies of enhancing students to develop framework of testing the prototype

The authors examine how pre-service teachers provide the strategies of enhancing students to develop framework of testing the prototype. This examining shows that they perceived how to enhance students’ integration knowledge of STEM. It found that they providing the questions to remind not only science and mathematics knowledge but also the techniques, value and culture.

(6) Providing the ideas of enhancing students to present their prototype.

It found that two of ten pre-service teachers provided some questions to remind students to reflect what knowledge was applying on the ways of designing.

**Pre-service teachers’ ideas of research about STEM education**

The school internship allowed pre-service teachers to practice their teaching and classroom research for 2 semesters – totally 10 months. For first semester, there are seven of ten pre-service teachers who could develop ideas for STEM education research. Their ideas of research aimed to provide the STEM education learning activities in order to enhance students’ 21st century skills. The rest of them should develop the classroom research by the second semester. These skills include students’ applying STEM knowledge for problem solving, creative thinking, critical thinking, and analytical thinking. The pre-service teachers’ classroom research topics are provided in the Table 1.

| Pre-service teachers’ name (pseudonym) | Research topics |
|--------------------------------------|----------------|
| Mr. Jay | The study of Grade 11 students’ creative thinking on STEM education learning about rotation motion |
| Ms. Tanya | Grade 10 students’ understanding on the relation between science, technology, engineering, and mathematics through the STS friction force unit |
| Mr. Tee | Enhancing Grade 10 students’ analytical thinking skills in STEM education learning activities about wave |
| Ms. Uma | Enhancing Grade 11 students’ analytical thinking skills in STEM education learning activities about lights and optics |
| Ms. Chon | The Study of engineering process design in STEM education learning activities about sound pollutions |
| Ms. Maprang | Examing Grade 10 students’ creative thinking on packaging STEM education |
| Ms. Nopporn | Enhancing Grade 11 students’ creative thinking in STEM education learning activities about lights and optics |

**6. Conclusion**

The share vision of STEM education, the participants were asked to reflect on what they agreement on STEM education. This indicated that the participants held good conception of STEM education. They understood the teaching strategies to provide the learning activities of STEM education. Some of them are aware of the nature of integration between science, technology, engineering, and mathematics. The enhancing of pre-service teachers generating ideas for developing STEM education lesson plan and practicing their teaching and classroom revealed that majority of them held well understanding of organizing STEM education in school setting.
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