Vietnamese pre-service teachers and in-service teachers’ conception of STEM Education

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Abstract. Recently, STEM education has emphasized in many countries including Vietnam because of its’ benefits. To prepare for effective STEM education instruction, the role of education universities in training pre-service teachers is concerned. To support training of STEM teaching instruction in classrooms for pre-service teachers, it is necessary to know their conceptualization of STEM conception and differences of their views with in-service teachers’ conceptions so that pre-service teachers work more effectively in their internship and near future in schools. However, little has been reported on how pre-service teachers are conceptualizing STEM education, and differences between pre-service teachers and in-service teachers’ STEM education conception who have more experiences in real classrooms in Mekong, Delta, Vietnam. In this study, to explore their STEM conception, an open-ended survey collecting both textual and visual responses was given to 100 in-service teachers from 10 schools in Can Tho city and 185 pre-service teachers of the Physics teacher education program, Can Tho University, Vietnam. The findings showed that both in-service teachers and pre-service teachers keep various ideas about STEM conception. They have both similarities and differences in conceptualization.

1. Introduction

Recently, education for Science, Technology, Engineering and Mathematics knowledge known as STEM education has been emphasized in many documents of many countries [1]. For K12 science education, an integrative approach has been suggested in many individual STEM standard documents such as a framework for K-12 science education [2] and the Next Generation Science Standards [3].

In Vietnam, an integrative approach has called in new education reforms of the country. For example, instruction no. 404BucCha/QĐ-TTG at 27/3/2015 of Prime Minister signed project for curriculum and textbook reform at K-12 education “new curriculum and textbook are built and compiled with integration at lower levels, suitably combining related contents to create integrated subjects, suitably decreasing the number of subjects, avoiding overlapping content and knowledge which are not necessary for students…” [4]. In new curricular applying on the school year 2019, with a competency-based approach, answers for questions “what will students do? And how to do?” were given at the end of each learning period. The competency-based approach requires students not only good at knowledge, basic skills but also ability application of knowledge, skills into practice, solving problems in their study and life [5]. STEM education has been concerned in schools as a good way to develop students’ competences. Therefore, in the school plan from the academic year 2016-2017, 1/9/2016 Ministry of education and training wrote: “Increasing application of problem-based learning, project-based learning,
actively using information communication technology (ICT) in teaching......for secondary education, get ideas of STEM education into practice of related subjects at the secondary level” [6].

New standards for science education require the next generation of science teachers who have the ability to integrated teaching. There is a need for preparing teachers proficient in applying integrated teaching in general and STEM instructional approach in specific, especially pre-service teachers who are becoming pioneering teaching force for the new curriculum. To create more effective STEM training instruction, it is necessary to know how pre-service teachers are keeping STEM conception and look at other views from in-service teachers who are teaching in real classrooms. Therefore, this study aims to explore pre-service teachers and in-service teachers’ conceptualization of STEM and make a comparison between them. The research question guiding this study is “how are in-service teachers' and pre-service teachers’ perceptions about STEM education conception?”

2. Conceptions of STEM Education

STEM can be defined differently by educators who are attempting to design programs and courses for improved student learning. At times, STEM is simply used as a way to discuss the four disciplines. At other times, the importance of integrating the fields is stressed [7]. In acknowledging the lack of agreed-upon definition, the California Department of Education (2014) provides a broad range of perspectives on STEM education, namely, “STEM....is used to identify individual subjects, a stand-alone course, a sequence of courses, activities involving any of the four areas, a STEM-related course, or an interconnected or integrated program of study” [8]. Stakeholders kept diverse perspectives. From an educational perspective, the introduction to STEM can be a variety of activities, but it usually focuses on more inquiry teaching strategies and a project-based approach instead of teaching traditionally. The other perspective is that it only becomes STEM when integrating science, technology, engineering, and math curricular that more closely parallels the work of a real-life scientist or engineer. To others, STEM is the push for graduating more students in the science, technology, engineering, and mathematics fields [9]. STEM can be a way to show scientific applications, a multidisciplinary approach, or a new integrative subject labelled as STEM [1].

In Bybee’s publication chapter 8 “What is your perspective of STEM education”, he presented nine different perspectives of STEM education based on many discussions, articles, reports, and projects [10]. These perspectives are suitable for the classification of Roberts and Cantu [11]. They proposed three instructional models that can be used in teaching STEM: the silo, embedded, and integration. Silo is the STEM disciplines taught in isolation. Embedding is view emphasizing science content while bringing in engineering and technology concepts that are not assessed. Integration refers to addressing the content of each STEM domain in a common context with lesson objectives and assessments tied to each of the STEM disciplines.

3. Method

3.1. Research design

In this study, we use a survey research design to investigate in-service teachers' and pre-service teachers’ conception of STEM education.

3.2. Participants

The participants included 100 in-service teachers from 10 random public high schools in Can Tho city, Vietnam and 185 pre-service teachers of the Physic education program, Can Tho University in Mekong Delta, Vietnam. These pre-service teachers involved 62 males and 123 females. The number of final year students is 89, 86 for third-year students and 10 for second-year students. In-service teachers consist of 69 females and 31 males, and 38 Physics, 30 Chemistry, 30 Biology, 1 chemistry and biology, 1 technology. Their ages are from 24 to 54 years old. The average age is nearly 37 years old. Almost in-service teachers had teaching experience in schools, specifically, the number of teachers who have teaching experience under 10 years are 30 people, more than 10 years are 61 people.
3.3. Instrumentation

We used a questionnaire developed by Radloff and Guzey [12]. It comprises two parts. Part 1 are 5 multiple-choice questions asked about the background information of the participants including gender, major, age, level of teaching, and teaching experience. Part 2 consists of 4 open-ended questions and one question utilizing a Likert scale. In part 2, Question 6 defined S, T, E, M and asked what characteristics STEM instruction is different from other types of instructional methods. Question 7 asked how STEM disciplines are connected, and it uses a Likert scale from 0 to 10 showing from not connected level to well-connected level. Question 8 asked their explanation about the level of connection that they chose. These questions explore the conceptual understanding of STEM education. Question 9 required drawing a diagram about how they visualize STEM using the letters S, T, E, M and question 10 asked their explanation about their drawing. Questions 6-8 collected textual answers supporting analyses of visualizing responses of questions 9-10. Visualization is proved to help students integrate new scientific information [13], and unobserved phenomena can be easily understood by a diagram or imagining [14]. Therefore, to elicit a STEM conception understanding of in-service teachers and pre-service teachers, it is beneficial if we connect collecting both textual data and visual data from participants.

3.4. Survey validation

Before implementation, the instrument was tested for conformity with the context, clarity of the questions ensuring participants understand clearly. The survey was translated to Tieng Viet and checked translation by a Vietnamese lecturer who got a doctoral degree in oversea and very good at technical English in science education. Then it was passed out to 34 bachelor’s degree students of the Physic education department. These students spent 20 minutes finishing the survey and gave feedbacks about some words making them difficult to understand. Based on this feedback, we adjusted some details to make questions better understanding.

3.5. Data collection

Data were collected over one month period at the end of August and beginning of September of 2017. We organized a workshop about STEM education and many students who are interested in STEM came attending. Before the workshop, we passed out of the survey for them. We collected a large amount of data from pre-service teachers. To collect data from in-service teachers, we came to every school, asked help from the principles of that school. The principles called STEM teachers such as Physics, Chemistry, Biology coming to a meeting and they finished the survey at the meeting without consult other information channels such as the internet.

3.6. Data analysis

The study used constant comparative methodology [15] in analyzing data and interrater reliability based on the procedure suggested [16]. First, both researchers preliminary checked all data to discard data that doubt reliability, then started independently coding some small samples using Bybee’s perspectives of STEM education. They met together afterward, and sample data were discussed until agreement among researchers about interpretation and codes and sample data coded again. Teachers’ responses were gathered into a spreadsheet and noted similarities and differences to categorize. We independently interpreted questions 6-8 to probe point of view from textual STEM conceptions with questions 9-10 to elicit understand from visual STEM conceptions. After that, we combined both points of view from text and visualization to elicit teachers’ conception of STEM education. In the second-round analysis, all data were coded and rearranged into categories cross-checked by the research team. Finally, the view about STEM education of two groups was compared and contrasted.

4. Result

In-service teachers' and pre-service teachers’ perspectives about STEM education were presented in the below chart (figure 1).
There were 8 main types of views including (1) integration of 4 disciplines S, T, E, M, (2) integration of T, E, M to learn Science, (3) emphasizing on one component of STEM, (4) an instruction, (5) connection of S, T, E, M, (6) unclear ideas, (7) others, (8) no answers. Overall, both in-service teachers and pre-service teachers kept various ideas about the conception of STEM education, and pre-service teachers keep more diversity about the conception of STEM education.

The view getting the highest percentage of attention in both groups is the integration of 4 disciplines S, T, E, M, slightly over 37% for the pre-service teacher group and approximately 31% for the in-service teacher group. While vision about the integration of T, E, M to learn science is much more selected by in-service teachers than by pre-service teachers. The figure is around 22% and 9% respectively. Likewise, pre-service teachers understood STEM education as an instruction for developing students’ competences generally more than in-service teachers. The number for their concern is slightly over 18% and 8% respectively.

The third perspective that many in-service teachers showed in their response is that STEM is an emphasis on one component of STEM which they put important level into specific elements such as technology, or engineering, or math. This figure is quite high for in-service teachers, nearly 20% but only more than 9% for pre-service teachers. In contrast, around 14% of pre-service teachers kept other alternative perspectives about STEM education while no in-service teachers fall in this category. In-service teachers mainly showed their view focusing on some points. Understanding STEM education as a connection of science, technology, engineering, and math was concerned by in-service teachers with approximately 8% while only slightly over 2% of pre-service teachers owned this view. Finally, both groups did not show their ideas or kept unclear ideas about STEM education conception, around 6% and 5% for in-service teachers and 2% and 9% for pre-service teachers respectively.

We present details of interpretation in every category for both groups as follows. Explanation in every classification is organized from both textual STEM conception and visual STEM conception.

4.1. The view 1: STEM education is an integration of 4 disciplines S, T, E, M
This category identified responses that mentioned integrated teaching of S, T, E, M. They concerned integration to develop knowledge and skills of S, T, E, M through practice, a connection of disciplines S, T, E, M to solve a real-world problem, develop students’ competences, or learning by doing with real-
world problems to develop knowledge and skills of 4 disciplines by following sequentially in real experience. An example of their ideas is as:

“Characteristics of STEM education are that it equips the necessary knowledge and skills for learners in fields of science, technology, engineering, mathematics. These knowledge and skills are integrated and support each other so that it makes students not only understand principles, theory but also practices and create products in daily life. STEM education narrows distance between theory and practice”

They also thought that integration knowledge of science, technology, engineering, and math in a theme to be a complete unit helps students have application ability in real life. They emphasized integration bring knowledge to students by practices, not theory that help students deeply understand knowledge. Most of the responses in this category selected a well-connected level among science, technology, engineering, math. They realized that technology and engineering are connected to science and math in real-life products, real-world applications, so it brings to students knowledge applicable and practical. Here we illustrate some visualizations that support textual responses to probe the view about the integration of 4 disciplines.

Figure 2. Visual representations for view of integration of 4 discipline S,T,E,M

Visualizations in letter (a) and (b) suggested tight connection knowledge and skills of science, technology, engineering and math, and these skills need to equip for students in modern society. Visualization letter (c) showed a connection of 4 disciplines to create a unit that develops creation for students. Visualization (d) portrayed the integration of science, technology, engineering, and math under a theme. Visualization (e) drew a tree connecting skills of science, technology, engineering, and math that signified the view of STEM in which integration of 4 disciplines in teaching help students understand the knowledge and develop competences for daily life. Visualization (f) illustrated a modern head needing knowledge and skills from S, T, E, M and they interact with each other. Visualization (g) presented integration knowledge and skills to solve real-world problems starting from math, then to science, and both science and math connected in engineering to create technology. Visualization (h) displayed a view of STEM as integration by sequencing disciplines in a course starting from math, then engineering, science, technology.

In-service teachers had a clearer explanation of their understanding than pre-service teachers. In-service teachers presented more detailed textual responds about the integration of 4 disciplines and provided diverse visualizations that support for their view while pre-service teachers answered simple textual response, for example, “technology and engineering lead students to practice, create a product based on knowledge of science and math”, “that is an integration of skills science, technology, engineering, and math”, and they illustrated fewer types of visualization for their view, mainly focused on visualization letter c, d, f and showed mutual interaction between S, T, E, M.
The view of this participants was quite similar with current integrated STEM perspective in literature in which integration of knowledge and skills of S, T, E, M in solving real-world problems or referring a specific theme suggested a completely integrative view of STEM [10]. Sequencing disciplines can be integrated into a unit through the process of investigating a scientific problem or solving an engineering design challenge [10].

4.2. The view 2: STEM education is an integration of T, E, M to learn science
Other participants defined STEM education as integration of T, E, M to learn science. In this perspective, they see that teachers use the integration of T, E, M in social issues to teach science, develop students' competences in real-world applications. Some responses viewed learning science by conducting scientific research needing a support of T, E, M. They focused on component science in STEM. Science education is a basic of STEM. Some others viewed STEM as learning science and applying science into real-life by engineering. The example of their ideas is as:

“This is a science instruction that incorporates technology, engineering, and math within it, help enhance teaching effectiveness… students construct their knowledge from suggesting hypothesis, built models, the calculation in analysis and concluding”.

Participants highly evaluated connection among S, T, E, M. They explained for their selection that connection of T, E, M can be seen in doing science. Examples of visualization support for textual conception as indicated in figure 3.

Figure 3. Visual representation of view integration of T, E, M to learn science.

Visualization in letter (i) showed that technology, engineering, and math are tools supporting to discover scientific knowledge. This viewed that learning science by the integration of T, E, M in scientific research. Visualization (j) illustrated that the development of science is based on the development of math, engineering, and technology. They saw the necessary of T, E, M in doing science. Visualization (k) demonstrated the junction of T, E, M in science. T, E, M are incorporated to discover the nature of phenomena. Visualization (l) illustrated view of the integration of T, E, M to study science,
for example, the study of the solar system needs to know microscope, calculation distance of stars, solar panels.

Pre-service teachers explained visualization (i) that “to teach science, science is a center and other components support it to make science content clear, accuracy”. Some responses identified that science is Physics, application of S, T, E, M (STEM) in teaching Physics. This view fitted with the perspective found in the literature in which science is overarching disciplines, a science teaching approach that connected by concepts of technology and engineering [10].

4.3. The view 3: STEM education is an emphasis on one component of STEM
Participants holding this perspective showed that they saw the connection of science, technology, engineering, math but they assumed that STEM is an emphasis on one component or special characteristic of STEM such as math or technology. For example, STEM emphasizes on the role of Math, Math is a common point of S, T, E. S, T, E, M have connectedness, but STEM education emphasizes on technology. The characteristic of STEM is technology or engineering to develop creativity. Characteristic of STEM is a logic of science or STEM emphasizes on engineering skills. Example of their response is as:
“Characteristic of STEM is math and learning by doing” or “characteristic of STEM is technology”.

They selected a well-connected level among S, T, E, M. However, they explained for their selection that math is basic of science, technology, and engineering. They focused on the importance of math in STEM. Similarity for other components of STEM such as technology. The following visualization will support for interpretation textual conception (figure 4).

![Visualization examples](image)

**Figure 4.** Visual representation of view emphasizing on 1 component of STEM.

Visualization letter (m) showed that math is the foundation of science, technology, engineering. They emphasized the importance of math in STEM. Visualization (n) illustrated the connection of science. Technology, engineering, and math in which math is considered as an important basis connecting other disciplines. Visualization (o) signified science is the basis of solving other subjects. Visualization (p) showed technology is a center supporting M, E, S. Participants involving this view focused on one special or common characteristic that they can see in STEM such as math or technology that did not fit in literature.
4.4. The view 4: STEM education is an instruction
Participants in this category only saw the interaction of science, technology, engineering, and math but they did not perceive in detail what STEM education is. They just suggest STEM is an instruction that develops students’ competencies, connect reality, hand-on, creative experience, solve a real-world problem, student-centered approach, learning by doing, learning by experimenting. Example of some following visualizations that support their understanding (figure 5).

![Visualization(q)](image1)

Figure 5. Visual representation of view STEM as an instruction

Visualization letter (q) showed that STEM is a learning instruction connecting theory with reality in which science and math are a theory, technology, and engineering are practice. Visualization (r, s, t, u, v) illustrated interaction and connection of S, T, E, M. This response did not show clearly what STEM is, just suggest this is an instruction to develop students’ competences. However, the characteristics of instruction mentioned in this category found in the literature for characteristics of STEM teaching such as hand-on, learning by doing, real-world application context [12].

4.5. The view 5: STEM education is a show of connection of S, T, E, M
This category viewed STEM as a connection of S, T, E, M but they did not realize what STEM education is. They saw a connection among S, T, E, M but just said that STEM education is different from other instructions that it shows the relationship between these disciplines. An example of this view is as:

“Characteristics of STEM education different from other instructions is showing a connection between science, technology, engineering and math in practice”.

Secondary school students can be enhanced their ability in solving real-world problems and application knowledge into daily life if they can see a connection of subjects in reality [3]. Therefore, showing the connection of S, T, E, M in STEM lessons is an important characteristic.

4.6. Others
Pre-service teachers hold other diverse perspectives but it did not suitable with current views in the literature that can be seen as misconceptions. Codes in this category such as applying high technology and engineering help students actual contact, enhance interest, incorporation of many different teaching methods from S (working scientifically), T (using information technology), E (the technique of
teaching), M (do the maths), teaching scientifically, apply many technologies, apply into engineering life, using math, using technology and engineering into teaching to enhance teaching effectiveness, apply new technology and information technology for teaching, connect many kinds of knowledge for teaching. They emphasized on using high technology and engineering. We found that when they explained their ideas, they showed misconceptions about definitions of concepts science, technology, and engineering. For example, science is working scientifically, engineering is a technique of teaching or production process is technology and equipment for production is engineering. Connection of science, technology, engineering and math in responses of this category were selected at a high level, however, participants only illustrated interaction between them in visualization but did not present their ideas.

Some participants did not answer the questions. Others presented their ideas unclearly. For example, “applying for advances, goodness into teaching” or “discover something around”, “educational innovation needs to systematize the fields”. These responses are in categories 8 and 6.

5. Discussions and Conclusion
Generally, a range of perspectives was probed from participants both in-service teachers and pre-service teachers. This is not surprised when a variety conception of STEM education was also found in the literature. However, most of their views can be interpreted following Bybee’s perspectives that he summarized from many reports and researches such as integration of 4 disciplines including science, technology, engineering, and math, integration of T, E, M to learn Science, an instruction, and connection of S, T, E, M.

Both in-service teachers and pre-service teachers hold the same perspectives such as integration of 4 disciplines with the highest percentage while they own opposite percentages in other perspectives. The second highest perspective among in-service teachers is an integration of T, E, M to learn science and next is an emphasis on one component of STEM while the second-highest position among pre-service teachers is the view of instruction and next is other multiple kinds of perspectives. This means that pre-service teachers kept more various perspectives on STEM education than in-service teachers and their uncertain understanding of STEM education in teaching science. In contrast, in-service teachers had a clearer understanding of STEM education conception through their explanation connecting with their teaching subjects. We might interpret this result by looking at different experiences among them. In-service teachers had more teaching experiences at schools with their subjects, so when they explain about their views, they tend to look at their teaching subjects, specifically science, and they used evidence when they teach their subjects for their explanation, while pre-service teachers talked very generally.

This research provides STEM education perspectives of pre-service teachers and differences of their views with in-service teachers’ views. These findings showed that it is necessary to provide a suitable STEM instruction course for pre-service teachers, help them clearly understand the perspectives that they would like to follow in their teaching at schools. The findings are also useful for science education programs, researchers who would like to design activities enhancing STEM education understanding for pre-service teachers.

6. References
[1] Ritz J M and Fan S-C 2015 STEM and technology education: international state-of-the-art Int. J. Technol. Des. Educ. 25 429–51
[2] National Research Council 2011 A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (Washington, DC: The National Academies Press)
[3] NGSS Lead States 2013 Next Generation Science Standards: For States, By States (Washington, D.C.: National Academies Press)
[4] Prime Minister 2015 404/QĐ-TTg: scheme of reforming K-12 curriculum and textbook
[5] MOET 2018 new general education curriculum
[6] MOET 2016 Official correspondence 4325/BGDĐT-GDTrH
[7] Morrison J and Bartlett B B 2009 STEM as a Curriculum - Education Week Educ. Week 8 28–31
[8] California department of education 2014 Science, Technology, Engineering, & Mathematics - Science (CA: Dept of Education)

[9] Breiner J M, Harkness S S, Johnson C C and Koehler C M 2012 What Is STEM? A Discussion About Conceptions of STEM in Education and Partnerships: What Is STEM? Sch. Sci. Math. 112 3–11

[10] Bybee R W 2013 The Case for Stem Education: Challenges and Opportunities (Arlington: NSTA Press)

[11] Annetta L A and Minogue J 2016 Connecting Science and Engineering Education Practices in Meaningful Ways vol 44 (Cham: Springer International Publishing)

[12] Radloff J and Guzey S 2016 Investigating Preservice STEM Teacher Conceptions of STEM Education J. Sci. Educ. Technol. 25 759–74

[13] Roth W-M, Bowen G M and McGinn M K 1999 Differences in graph-related practices between high school biology textbooks and scientific ecology journals J. Res. Sci. Teach 36 977–1019

[14] Buckley B C 2000 Interactive multimedia and model-based learning in biology Int. J. Sci. Educ. 22 895–935

[15] Glaser B G and Strauss A L 1967 The discovery of grounded theory: strategies for qualitative research (New Brunswick: Aldine Transaction)

[16] Charmaz K 2006 Constructing grounded theory: a practical guide through qualitative analysis (London: SAGE)

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