Pre-service teachers’ integrated curriculum approaches to STEM education in classrooms

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Abstract. This study aims to explore the integration approach employed by pre-service teachers in their STEM lessons. In-depth interviews with six pre-service mathematics teachers and ten pre-service sciences teachers from Lampang Rajabhat University were employed. The interviews were analyzed using the conceptual framework of the curricula integration model described by Robin Fogarty, focusing on the approaches used by pre-service teachers to STEM education. The study revealed that most participated pre-service teachers use connected and shared approaches to STEM education, and they only appeared if standard textbooks provide a guideline. The use of the integrated approach across disciplines by pre-service teachers is infrequent. This study also revealed that pre-service teachers reject subject-integration in their classroom as well as the necessity of implementing technology in their teaching because of time limitations. The findings of this study possess practical importance that they can be utilized for the modification of teacher education and training programs in Lampang Rajabhat University. Consideration of the findings may contribute to the development of the Thailand National Core Curriculum and its objectives. Additionally, there was a contribution to add literature to STEM education in Thailand.

1. Introduction

In the 1990s, the National Science Foundation began using the term STEM as an abbreviation for science (S), technology (T), engineering (E), and mathematics (M). Since the US Congress presented the “Action Plan for STEM Education” in 2007, STEM integration education has emerged as an alternative to increase interest in students’ literacy of science, mathematics, engineering, and technology. In science and mathematics education, students’ achievement and interests have been significantly lowered, lack of awareness and misunderstanding in technical education, and the case of engineering, the lack of students entering engineering colleges, and the lack of female participation students in engineering programs. Therefore, while addressing each field’s education problems, integration was suggested as an essential solution. STEM education aims to achieve integrated learning by approaching science, technology, engineering, and mathematics aspects with a single subject, which not only enhances learning efficiency but also facilitates the interest and motivation of students [1]. However, it is not easy to develop a suitable model for a single subject that can be accessed in various fields. Since it requires an integrated understanding between various disciplines, it is necessary to develop the convergent learning activities and materials for students and integrate curriculum properly [2]. In order to achieve STEM education implementation, integration between subjects was suggested as an essential solution.
In Thailand, various education policies for STEM education have been developed so that sciences and mathematics education crossing various disciplines and various education policies to develop creative and convergent human resources was expecting to be developed and implemented. However, it was not easy to develop a suitable model for a field while being accessible in various STEM education fields. So, it is necessary for a prospective teacher who has to lead students to their achievement because it requires an integrated understanding of various disciplines. Additionally, a required variety of competencies for prospective teachers according to those policies included how they approached STEM education in their actual classrooms.

Therefore, in this study, six pre-service mathematics teachers and ten pre-service sciences teachers for their school practicum were selected and analyzed to explore how they employed the integration approaches in the STEM lessons. Based on the results of this study, we analyzed the types of integration with other subjects according to the curricula integration model proposed by Robin Fogarty [3], primarily to which approach do the participated pre-service teachers used in their STEM lesson?

2. Literature Review

This study manipulated the curricula integration model proposed by Robin Fogarty [3], to be called as the integration approaches in this study, as the focal point.

![Figure 1. Ten curricula integration models [3]](image)

Figure 1 shows the curricula integration model that can be classified into ten approaches as within a single discipline form: 1) fragmented, 2) connected, and 3) nested; across the disciplines form: 4) sequenced, 5) shared 6) webbed, 7) threaded, 8) integrated; within and across learners form: 9) immersed and 10) networked. The detail of each type is as in table 1.

| Model Type | Description | Advantage | Disadvantage |
|------------|-------------|-----------|--------------|
| 1. Fragmented | Dictate separate and distinct disciplines. | Clear and discrete view of a discipline. | Connections are not made clear for students; less transfer of learning. |
| 2. Connected | Focus on the details, subtleties, and interconnections | Leading to the review, reconceptualization and assimilation of disciplines | Disciplines are not related; content focus |
within an individual discipline. ideas within a disciplinary. remains within the discipline.

3. Nested
Take advantage of natural combinations and be performed by overtly making connections or creating combinations.
Give attention to several areas at once, leading to enriched and enhanced learning.
Students maybe confused and lose sight of the main concepts of the activity or lesson.

Form Two: Across the Disciplines

4. Sequenced
Topics and units are taught independently, but they are arranged and sequenced to provide a framework for related concepts.
Facilitates transfer of learning across content areas.
Require ongoing collaboration and flexibility, as teachers have less autonomy in sequencing curricula.

5. Shared
Bring two distinct disciplines together into a single focus.
Shared instructional experiences; with two teachers on a team it is less difficult to collaborate.
Require time, flexibility, commitment and compromise.

6. Webbed
Use a fertile theme to integrate subject matter and provide a greater opportunity for teachers of various disciplines to find common topics, concepts and skills.
Motivating for students, helps students see connections between ideas.
Theme must be carefully and thoughtfully selected to be meaningful, with relevant and rigorous content.

7. Threaded
Thread thinking skills, social skills, study skills, graphic
Students learn how they are learning,
Disciplines remain separate.
organizers, technology, and multiple intelligences approach to thinking throughout all disciplines.

facilitating future transfer of learning.

8. Integrated

Interdisciplinary topics are arranged around overlapping concepts and emergent patterns. This process blends the disciplines by finding overlapping skills, concepts, and attitudes found across the disciplines.

Encourage students to see interconnectedness and interrelationships among discipline, students are motivated as they see these connections.

Require interdepartmental teams with common planning and teaching time.

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| Form Three: Within and Across Learners |
|----------------------------------------|
| **9. Immersed**                        | **Integration takes place within the learner.** | **May narrow the focus of the learner.** |
| Integration takes place within the learners, with little or No. outside intervention. | | |

| **10. Networked**                       | Pro-active, with learner stimulated by new information, skills or concepts. | Learner can be spread too thin, efforts become ineffective. |
| Create multiple dimensions and directions of focus and provide various ideas and ways of discovering. | | |

STEM education should be conducted to foster creative convergence talent rather than educating only with knowledge. As prospective teachers, it is difficult to progress to other parts of the curriculum other than each subject in the present educational situation. Even if this was done, it could only be a combination of subjects. Therefore, it is necessary to find common elements among the subjects both within a discipline and across disciplines to construct an integrated STEM education curriculum. So, Fogarty’s curricula integration can be beneficial by providing a learning environment that enables students to make a convergent understanding within and across subjects.
3. Methods
The qualitative research method by Creswell [4] was employed to answer the research question of which approach the participated pre-service teachers used in their STEM lesson. The pre-service teachers from Lampang Rajabhat University were selected to participate in in-depth interviews through purposive sampling [5].

An interview protocol was developed for in-depth interviews consisting of four sections:

• Pre-service teacher education and training opportunities about STEM
• Understanding of STEM and its objectives
• Practice and experience of using integration approach
• General teaching approaches and attitudes

The data were recorded, transcribed, and then analyzed under the framework of the integration approaches defined from the integrated curriculum model by Robin Fogarty.

4. Result and Discussion

4.1. Definition of STEM education by pre-service teachers
The participants’ interviews demonstrated that pre-service teachers were not aware of STEM education and its objectives. They only have a limited understanding of this issue. Manifested below are several explanations that broadly reflect the explanations provided by all pre-service teachers. Most pre-service teachers connect STEM education with the combination of sciences, technology, engineering, and mathematics:

• “Supposedly, the content of different subjects is considered as was their combination with more than two subjects.”

Some pre-service teachers believe that STEM education means raising awareness of teaching more than a single discipline. As one participant stated, STEM education means:

• “To understand each discipline’s core content and comprehend the integration among them as well.”

A few pre-service teachers consider that STEM education aims to foster useful integrations among disciplines and help students understanding all related contents. However, some of the pre-service teachers tried to explain the term “STEM education” using the direct translation of the abbreviation of STEM:

• “In my opinion, STEM is the curriculum of the subjects in sciences, technology, engineering, and mathematics [...]”

In conclusion, it was found that the participants had a limited understanding of STEM education and its objective. So, it could directly affect their intention of how they could advance the implementation of STEM education.

4.2. Approaches to STEM education utilized by pre-service teachers.
The majority of pre-service teachers used the lowest form of the integration approaches as within a single discipline to incorporate STEM education in their teaching. The participants mostly used the connected approach to STEM education. It was found that, during their teaching, they focused only on the details, subtleties, and interconnections within an individual discipline leading to the review, reconceptualization, and assimilation of ideas within one discipline. As they mentioned, they often discuss the connection of the content within a single discipline instead of across the disciplines:

• “The last activity I could recall about trigonometric function [...]. Students worked on the problems of force with more understanding and made a good solution. Students developed the solution using the trigonometric function from a mathematics subject”.
Although the shared approach represented the form of across the disciplines of STEM education was found from three participants in the study, they simply add a unit, chapter, or activity to the lesson plan without sophisticated integration, only bringing two distinct disciplines together into a single focus:

- “For example, we had a lesson – Instantaneous rate – and studied velocity in sciences subject, how it related to the instantaneous rate of change in mathematics subject”.

Furthermore, analysis of pre-service teachers’ interviews revealed that they rarely manage to integrate the curriculum into their teaching process and use the integrated approach, according to Fogarty, to STEM education. In the interviews, most pre-service teachers claimed that they might use the integrated approach if a standard textbook made it possible to do so. Additionally, if the learning standards, according to the national core curriculum, has been developed based on the integrated approach, it would be accessible to them to arrange interdisciplinary topics around overlapping concepts and emergent patterns:

- “If the textbook allows, I may try to use it and emphasized the integration process. The issue for discussion in the class was dependent on the time limitation”.

The results of this study underlined several discussions. Firstly, pre-service teachers regularly use the most straightforward and least practical approaches to STEM education: connected and shared approaches. Thus, it is crucially necessary to adjust the curriculum of teacher education, especially for sciences and mathematics education, on the integrated approaches and their effective utilization in the classroom setting. Teacher education program development may help teacher educators to identify pre-service teachers’ attitudes toward different integration approaches:

- “obtain the knowledge obliged to develop and implement an effective pedagogy for STEM lesson [...] as an integrated approach that encourages students to see interconnectedness and interrelationships among discipline as you introduced provides all [education program] students to achieve in effective curricula integration”.

Secondly, it was seen that a majority of pre-service teachers were very dependent on specific standards. This finding emphasized the fact that pre-service teachers simplified their teaching preparation by being dependent on standard textbooks and the Thailand national core curriculum since, in standard textbooks, students often study concepts and issues primarily within a single discipline while the integration across the discipline and within and across learners is mostly neglected. Thus, it is crucially important to work on the development of standard textbooks as well as improving the national core curriculum in using various integration approaches in the classrooms.

5. Conclusion
In conclusion, the contribution of this study may add literature to the field of STEM education in Thailand. Its findings have practical importance because they can be used to implement teacher education and training programs. Higher education institutions also have to revise their teacher education programs and consolidate STEM education courses as well as reflect the curricula integration in all outlines of the program. The findings of this study further revealed the significant consequence of such changes to the Thailand national core curriculum and its guideline for teaching to manifest the integrated approach in their lesson design. Consideration of findings also contributes that it is crucially important to work on developing standard textbooks in using various curricula integration approaches in the classrooms.

6. References
[1] National Research Council 2012 A Framework for K-12 Science Education: Practices, Crosscutting Concept, and Core Ideas (Washington: National Academy Press)
[2] Hong Y Y 2014 Pre-service teachers’ practical use of graphing calculators for STEAM education J. of Educational Information and Media 203 355–72
[3] Fogarty R 1991 Ten ways to integrate curriculum *Educational Leadership* **49** 2 61–5
[4] Creswell J W 2007 *Qualitative Inquiry and Research Design: Choosing among Five Approaches* 2nd (Thousand Oaks: Sage)
[5] Krathwohl D 2009 *Method of Educational and Social Sciences Research: The Logic of Methods* 3rd (New York: Longman)