

Pre-Service Teachers Perspectives on Stem – Science, Technology, Engineering, and Mathematics

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Abstract

Introduction. Science, Technology, Engineering, and Mathematics which is commonly abbreviated as STEM is one of the contemporary teaching and learning approaches in education. STEM is closely related to education in schools. Several studies wanted to find out how STEM influences students in teaching and learning. Research at the level of higher education has not been done much. More specifically, research on STEM among pre-service teachers has not been widely conducted. This study aims to determine how pre-service teachers perceive each aspect of STEM. **Methods.** The research method used in this research is qualitative. The data collection techniques in this study were interviews with 49 Pre-Service Teachers. The data obtained were then analyzed using coding techniques. **Results and Discussion.** The results of the data show that Pre-Service Teachers suggest activities of: (1) Involving Science Concept, (2) Making Experiment, (3) Measuring, (4) Observing, (5) Involving Scientific Phenomenon, and (6) Asking Scientific Questions on aspects of science. In the Technology aspect, the activities are: (1) Using Software, (2) Using Computer, (3) Using Internet and (4) Using Smartphone. In the Engineering aspect, the activities are: (1) Designing Problem Solving Procedure, (2) Making Product, and (3) Operating Tool. Meanwhile, in the Mathematics aspect, the activities are: (1) Using Numbers, (2) Calculating, (3) Finding Patterns, and (4) Using Formulas.

Keywords

activities, engineering, mathematics, perspectives, pre-service teacher, technology, sciences, STEM activities, STEM education, teaching STEM

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Introduction

Science, Technology, Engineering, and Mathematics which is commonly abbreviated as STEM is one of the contemporary teaching and learning approaches in education (Chiang, 2020; Chiang et al., 2019; Liu, Chubarkova & Kharakhordina, 2020; Makino et al., 2018; Wang & Chiang, 2020). Teaching and learning that uses the STEM approach will include aspects of science, technology, engineering, and mathematics in its teaching and learning. This approach has been adopted by many countries in the world (Dinh & Nguyen, 2020; Hartmann, Mouton & Ertl, 2022; Lee, Hsu & Chang, 2019; Plutzer & Hannah, 2018; Thibaut, Knipprath, Dehaene & Depaepe, 2018). In Southeast Asia, the Philippines is a country that has included STEM in its education curriculum. STEM in the Philippines has become a subject taught at the secondary school level. Currently there is a wide range of digital tools that can be used in science, technology, engineering and mathematics education (the STEM disciplines) during primary and secondary school (de las Cuevas, García-Arenas & Rico, 2022; Lowrie & Larkin, 2020; Purzer & Shelley, 2018; Saat et al., 2021; Simó, Lagarón & Rodríguez, 2020).

Unlike the Philippines, Indonesia has not included STEM in the curriculum. The absence of STEM in the education curriculum in Indonesia could be due to the absence of operational guidelines for including or integrating STEM in teaching and learning (Amany, 2023; Mutmainah, 2023). Research on the topic of STEM activities has been widely carried out in several journals (Fung, 2020; Kefalis & Drigas, 2019; Levanova et al., 2020; López-Díaz & Peña, 2022; Salar, 2021). Although the research has the topic of STEM activities, this research has not examined what activities can be applied to include or integrate STEM in teaching and learning. Therefore, research that examines what activities can be carried out in each aspect of STEM is important (Nicol et al., 2019; Sterrett et al., 2020; Yıldırım, 2020).

STEM is closely related to education in schools (Falloon et al., 2021; López & Cabello, 2022; Morales-Doyle & Gutstein, 2019; Nguyen, 2020). Several studies wanted to find out how STEM influences students in teaching and learning. Research at the level of higher education has not been done much. More specifically, research on STEM among pre-

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service teachers has not been widely conducted. From this description, this study aims to determine how pre-service teachers perceive each aspect of STEM.

Methods

The research method used is a qualitative research method. Meanwhile, the research approach in this study is the Grounded Theory approach. Grounded theory is a qualitative research approach that is used to create theories that explain problems at the level of a broad conceptual, process, action or interaction on a substantive topic (Creswell, 2009). The subjects in this study were Pre-Service Teachers from one of the universities in the city of Purwokerto.

Data Collection Tools

Data collection technique in this research is interview. Respondents from the interview were 49 Pre-Service Teachers. The interviews conducted consisted of 4 questions according to Table 1.

Table 1

Interviews Questions List

No.	Questions
1.	Tell me how did you integrating Science into your teaching and learning?
2.	Tell me how did you integrating Technology into your teaching and learning?
3.	Tell me how did you integrating Engineering into your teaching and learning?
4.	Tell me how did you integrating Mathematics into your teaching and learning?

Data Analysis

Data analysis is the process of systematically searching and compiling data obtained from interviews, field notes and other materials, so that they are easy to understand, and the findings can be informed to others (Bogdan & Bikien, 1998). Activities in qualitative data analysis are carried out interactively and take place continuously until complete until the data is saturated (Miles & A. Huberman, 1994). Activities in data analysis consist of data reduction, data display, and drawing conclusion/verification.

In addition to using these techniques, this study also uses qualitative data analysis techniques using coding. Coding is an activity to code an important information in a data. Code is a short word or phrase that summarizes, emphasizes the message, or captures

the essence of the data. In simple terms, code is a short word or phrase that has the essence of a segment in the data (Saldana, 2009).

Data Validity

The data validity technique is an effort to check the accuracy of the results of qualitative research by applying certain procedures. There are 3 types of data validity techniques, namely triangulation, member checking, and external auditing (Creswell, 2009). The validity of the data taken in this study is triangulation. Triangulation consists of 3 types, namely time triangulation, source triangulation, and technical triangulation (Sugiyono, 2015). This research uses source triangulation. Source triangulation in this study is a procedure for comparing data from 1 respondent with other respondents. If a data is found in more than 1 respondent, it means that the data is valid.

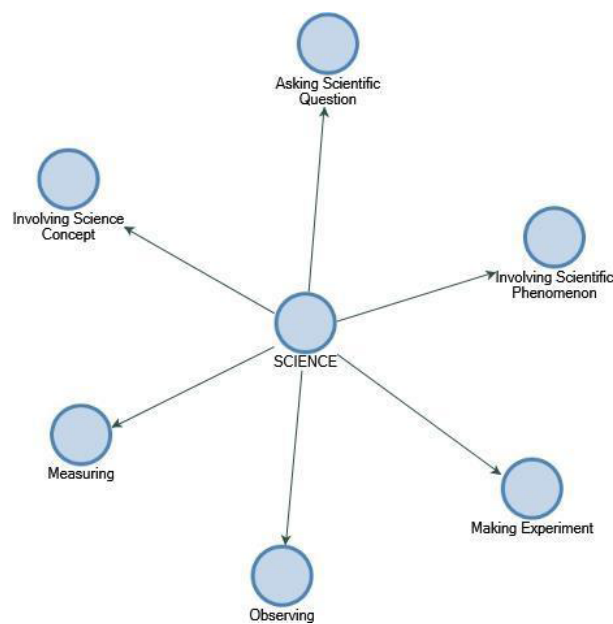
Results

Pre-Service Teachers Perspectives about Science in STEM

Pre-Service Teachers have 6 suggested activities that can be done in integrating Science in teaching and learning. The six activities are shown in Figure 1.

Figure 1

Pre-Service Teachers Perspectives about Science Activities



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The first activity that can be done to integrate Science in STEM is the Involving Science Concept. The statement of one respondent who mentioned the Involving Science Concept is as follows:

- "Science allows children to conduct experiments (experiments), what is meant in this case is not a complicated process that must be mastered by children to understand the concept of a thing but on how they can know the way or process of something happening and why something can happen."

This is also supported by other respondents as follows:

- "Science provides knowledge to students about the laws and concepts that apply in nature."

Some Pre-Service Teachers are of the view that Science in STEM can be done by Making Experiments. This was stated by one respondent as follows:

- "Inviting students to do experiments so that they can understand the concept of something, know the way or process of something happening and why something can happen."

In addition to the respondents above, there are other respondents who stated a similar statement as follows:

- "In each teaching and learning, it is expected that students are able to understand and apply the material that has been obtained during teaching and learning such as hands-on practice in places such as acid-base testing experiments, experiments using a microscope, etc. Educators must also be creative in teaching students so that students easily accept the material well."

Measuring is one of the activities that can be done in the Science aspect of STEM. This was stated by at least 2 respondents as follows:

- "By studying real events such as natural phenomena that occur that involve observation and measurement."
- "Science is an activity of exploring, observing, and conducting experiments. When they want to try a formula to calculate the height of a tree, students can be asked to go directly into the field, measure and observe for themselves."

Meanwhile, Observing is expressed by 5 respondents. Two statements are stated as follows:

- "Science is an activity of exploring, observing, and conducting experiments. When they want to try a formula to calculate the height of a tree, students can be asked to go directly into the field, measure and observe for themselves."
- "Linking teaching and learning materials with something that exists in nature. Bringing the teaching and learning process outside the room so you can observe the natural surroundings directly."

The last two findings found in the research were that several Pre-Service Teachers

stated that the activities that could be done in the Science aspect were Involving Scientific Phenomenon and Asking Scientific Questions. Some of the respondents' statements about these 2 activities are as follows:

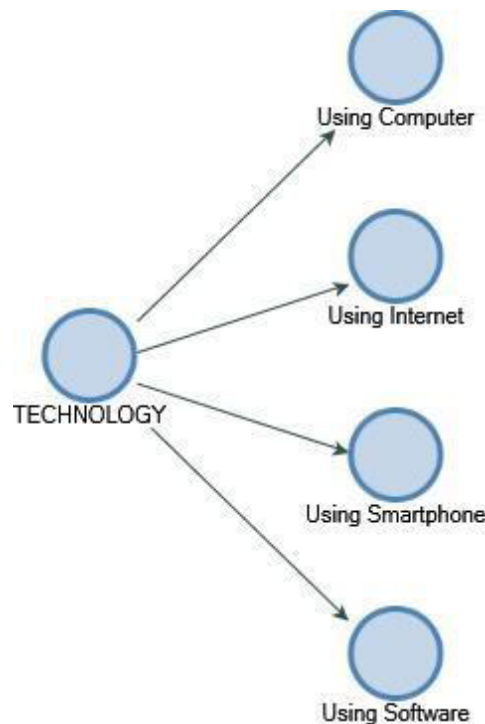
- "The element of science that I put into teaching and learning is about a logical thought about natural phenomena that is based on evidence."
- "Science is the study of natural events that involves investigation, research, and measurement to explain the causes and effects of natural phenomena."
- "To identify the evidence needed to answer scientific questions and answer(solve) problems in human life."
- "The trick is to relate the lessons learned to science by first asking scientific questions first."

Pre-Service Teachers Perspectives about Technology in STEM

In the Technology aspect, Pre-Service Teachers are of the view that integrating Technology in STEM can be done by using several assistive devices. Assistive devices that can be used such as Computer, Internet, Smartphone, and Software. This finding is in accordance with Figure 2.

Figure 2

Pre-Service Teachers Perspectives about Science Activities



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In contemporary teaching and learning, Using Computer and Software has often been used in teaching and learning. This is what causes some respondents to state that Using Computer and Software is one of the roles of Technology in STEM. One of the respondents who stated the statement was as follows:

- "Technology can also make it easier for students to find and increase access to teaching and learning. For example, such as applications that are used as a tool to help students understand the material other than that delivered by the teacher in the classroom."
- "To include elements of technology in teaching and learning, you can train the use of applications that support teaching and learning to students."
- "Training students' critical thinking skills in solving problems through collaboration and communication using computer technology."
- "By studying computer technology to support teaching and learning."

Using Smartphone in teaching and learning is not easy. However, Using Smartphone is one thing that can be done in integrating Technology in STEM. This was stated by one of the Pre-Service Teachers as follows.

- "Using a Smartphone connected to the internet when teaching and learning and also a laptop."

This is in line with the statement of other Pre-Service Teachers as follows:

- "I include elements of technology in teaching and learning, for example using a laptop or Smartphone in which there are several applications or media for teaching and learning with skills or a system that is used to regulate society, organization, knowledge or design and use an artificial tool that can facilitate profession."

The last finding on the Technology aspect is that several respondents stated that Technology activities can be done by Using the Internet. This finding is based on information from several respondents as follows:

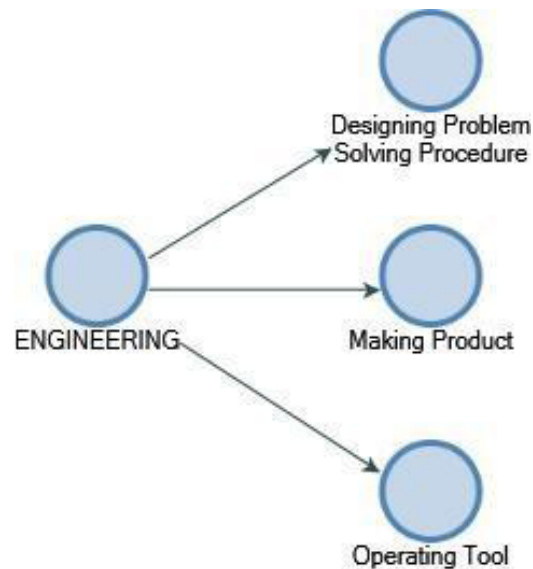
4. "Teaching and learning occasionally uses an LCD projector to play videos or deliver material in ppt format. Apart from that, they do teaching and learning using computer and internet media."
5. "Internet, computer programming, digital technology."

Pre-Service Teachers Perspectives about Engineering in STEM

In the engineering aspect, this study found 3 findings. These three findings are illustrated in Figure 3.

Figure 3

Pre-Service Teachers Perspectives about Engineering Activities



The first finding is Designing Problem Solving Procedure. This finding was stated by the most respondents compared to other findings. This finding was stated by 6 respondents. Some of his statements are as follows:

- "Provides knowledge to operate or design a procedure to solve a problem."
- "Operating or designing a procedure to solve a problem."

The next finding is Making Product. Product Making Activities are activities that can be done in the Engineering aspect in STEM. This is stated by the respondents as follows:

- "We can make or create something together with students to be able to learn something."

Other respondents also expressed the following opinion:

- "By making subjects on engineering where the goal is that students are expected to be able to make something useful in the future, with advanced technology, this is certainly very helpful."

The last finding on the Engineering aspect is the Operating Tool. Only 2 respondents stated this statement as follows:

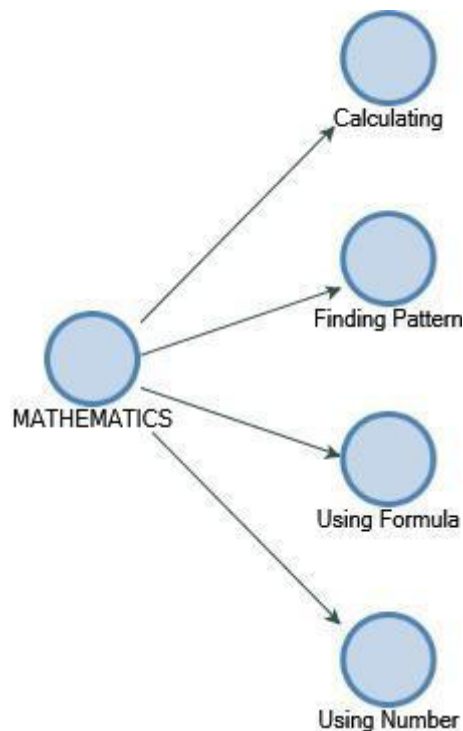
- "A person's skill in operating a tool/object or assembling something."
- "By inviting students to operate tools/objects or assemble something."

Pre-Service Teachers Perspectives about Mathematics in STEM

There are 4 activities that can be done in the Mathematics aspect in STEM according to Pre-Service Teachers. The four activities are in accordance with Figure 4.

Figure 4

Pre-Service Teachers Perspectives about Engineering Activities



Activities Calculating and Using Numbers are fundamental activities in Mathematics. Therefore, Calculating was expressed the most by Pre-Service Teachers when asked about the role of Mathematics in STEM. Some statements of Pre-Service Teachers are as follows:

- "Connecting between quantities, pattern numbers, and spaces requires only logical arguments without or accompanied by empirical evidence."
- "The linking of mathematical elements in teaching and learning can be provided by connecting quantities, numbers and spaces that only require logical arguments without or accompanied by empirical evidence."
- "Teaching logical calculations."
- "In everyday life, including in teaching and learning, students must relate to numbers or calculations. Students must be taught how to count carefully so that

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there are no errors in the calculations. In solving math problems there are many strategies or methods that students can use in solving these problems so students must be able to choose what strategies are easy to use in solving the problem.”

The next activity found in this research is Finding Pattern. Activities Finding Pattern is one of the core roles of Mathematics not only in STEM. These activities are described by one of the Pre-Service Teachers as follows:

- “Incorporating elements of mathematics in teaching and learning can be done by introducing through patterns and so on.”

Another Pre-Service Teacher also supports this statement by providing the following statement.

- “By using and applying patterns, relationships, numbers, quantities, and spaces and providing a language for Technology, Engineering, and Mathematics.”

The last activity found on the role of Mathematics in STEM is Using Formula. These activities are suggested by 8 Pre-Service Teachers with the following statements.

- “Incorporating some mathematical formulas or materials into teaching and learning.”
- “Exemplifying the formulas that exist in mathematics in everyday life.”

The STEM activities found in this study can be seen more easily in Table 2.

Table 2
STEM Activities

No.	STEM Aspect	Activities
1.	Science	1. Involving Science Concept 2. Making Experiment 3. Measuring 4. Observing 5. Involving Scientific Phenomenon 6. Asking Scientific Question

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No.	STEM Aspect	Activities
2.	Technology	<ol style="list-style-type: none"> 1. Using Software 2. Using Computer 3. Using Internet 4. Using Smartphone
3.	Engineering	<ol style="list-style-type: none"> 1. Designing Problem Solving Procedure 2. Making Product 3. Operating Tool
4.	Mathematics	<ol style="list-style-type: none"> 1. Using Number 2. Calculating 3. Finding Pattern 4. Using Formula

Discussion

Science, Technology, Engineering, and Mathematics (STEM) is an approach in teaching and learning that has been used for a long time. Research on STEM activities has been done. A study showed that giving videos to students during teaching and learning is one thing that can be done in STEM (Fung, 2020). However, there is no theory that provides explicit guidance in implementing STEM in the classroom. In fact, the provision of STEM in the classroom can improve student competence in the 21st century era (Hussin et al., 2019). Therefore, the activities found in this study can provide guidance in the use of STEM. These activities can help In-Service Teachers or Pre-Service Teachers in determining what activities can be done in each aspect of STEM (Salar, 2021).

STEM activities in the Science aspect include: (1) Involving Science Concept, (2) Making Experiment, (3) Measuring, (4) Observing, (5) Involving Scientific Phenomenon, and (6) Asking Scientific Questions. While in the Technology aspect, there are several activities including: (1) Using Software, (2) Using Computer, (3) Using Internet and (4) Using Smartphone. Activities in the Engineering aspect include: (1) Designing Problem Solving Procedure, (2) Making Product, and (3) Operating Tool. In the Mathematics aspect, STEM can be done through activities of: (1) Using Numbers, (2) Calculating, (3) Finding Patterns, and (4) Using Formulas. These activities can be used as a reference for other researchers in implementing STEM in teaching and learning in the classroom.

Conclusion

STEM is teaching and learning that integrates Science, Technology, Engineering, and Mathematics at once. In the Science aspect, In-Service or Pre-Service Teachers can perform activities of: (1) Involving Science Concept, (2) Making Experiment, (3) Measuring, (4) Observing, (5) Involving Scientific Phenomenon, and (6) Asking Scientific Questions. In the Technology aspect, the activities are: (1) Using Software, (2) Using Computer, (3) Using Internet, and (4) Using Smartphone. In the Engineering aspect, the activities are: (1) Designing Problem Solving Procedure, (2) Making Product, and (3) Operating Tool. Meanwhile, in the Mathematics aspect, the activities are: (1) Using Numbers, (2) Calculating, (3) Finding Patterns, and (4) Using Formulas.

- Science aspect activities in STEM are: (1) Involving Science Concept, (2) Making Experiment, (3) Measuring, (4) Observing, (5) Involving Scientific Phenomenon, and (6) Asking Scientific Questions.
- Technology aspect activities in STEM are: (1) Using Software, (2) Using Computer, (3) Using Internet and (4) Using Smartphone.
- Engineering aspect activities in STEM are: (1) Designing Problem Solving Procedure, (2) Making Product, and (3) Operating Tool.
- Mathematics aspect activities in STEM are: (1) Using Numbers, (2) Calculating, (3) Finding Patterns, and (4) Using Formulas.

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Conflict of Interest Information

The authors have no conflicts of interest to declare.