Pre-Service Teachers’ Perspectives: STEM as a Solution to Promote Education for Sustainable Development

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Abstract. Education plays an important role to build a sustainable development framework. To support the sustainable development framework, many researchers have constructed various methods, learning approaches, and learning models. STEM is one of the most popular learning approaches in the 21st century, although it has some issues such as the curriculum and structure, skills development, career exposure, evaluation, and the interrelationship between humans and nature. This research was aimed to measure pre-service teachers’ perspectives on the relationship between the implementation of STEM in education to support Education for Sustainable Development (ESD). Nine pre-service teachers from biology education and science education have been interviewed to comprehend the role of STEM in ESD. The result showed that there were different ideas from participants about STEM, ESD, and the advantage of STEM implementation to promote ESD. Further research should be conducted to develop and socialize STEM, specifically based on students’ characteristic, behavior, and culture in each country.

1. Introduction

Education is an important matter in the 21st century and a part of sustainable development program. As a part of sustainable development program, education should support environment, economy, and social development by producing human капиталs with good morals, capable of solving complex problems using their creativity [7], contributing to economic growth [2], and pro-environmental attitudes and behaviors [1]. The target of Education for Sustainable Development (ESD) is the younger generations who can integrate new mindset and behaviors that lead to a more sustainable development path [9].

Various problems have been emerged in the formal education system, such as quality of teacher and student, learning management, learning assessment, curriculum, and lesson plans. There are some ways to solve the problems like using an appropriate learning approach. STEM as a learning approach integrating science, technology, engineering, and mathematics is an effective way to address some of those complex issues [4]. Student as a product of education can lose their potential without adequate exposure to how STEM advanced studies and careers should be [13]. STEM implementation should improve students’ awareness and concern toward society, nature, and economic development. STEM is not something new in education terms. But, some people don’t understand about STEM, even among the pre-service teachers. Applying STEM to promote effective ESD must be supported by teachers’ knowledge and paradigm about STEM, ESD, and its advantage.
2. Methodology

This was a qualitative study. This research was conducted by using the pre-service teacher as a sample. Nine pre-service teachers were selected from science education and biology education from two universities in Central Java and Sumatra. They were asked to give their perspectives about STEM, ESD, and the advantage of STEM and ESD implementation. They were chosen by considering their knowledge about STEM and ESD. The pre-service teachers’ knowledge was mapped by using a need analysis questionnaire to 125 pre-service teachers. Data were collected by open-ended interviews with three questions based on STEM aspects. The first question was about their perspectives about STEM, the second was their perspectives about ESD, and the last was their perspectives about the advantage of STEM and ESD implementation.

The answer from participants was recorded and transcribed into numbered sentences to ease out the finding of the keyword from their answer. The transcripts were categorized into some themes, then further categorized into sub-themes. Data were analyzed with Ms. Excel and presented as the percentages.

3. Results and Discussions

3.1. Results

The result of pre-service teachers’ perspectives about STEM was shown in Table 1. Four themes were founded in research, and each theme has various subthemes. Those were the STEM role in learning science, STEM learning characteristics, the involvement of STEM elements in learning, and STEM learning goals.

STEM’s roles in learning science were divided into three sub-themes. Pre-service teachers presumed STEM as a method (1 of 9 pre-service teachers), model (2 of 9 pre-service teachers), and approach (3 of 9 pre-service teachers). STEM learning characteristics were divided into five sub-themes. There were innovative (2 of 9 pre-service teachers), problem-based (2 of 9 pre-service teachers), technology-based (4 of 9 pre-service teachers), computational thinking (1 of 9 pre-service teachers), and applicative (3 of 9 pre-service teachers). The involvement of STEM elements in learning was divided into two subthemes. Those were: there was one element included in STEM, and four elements included in STEM. 3 of 9 pre-service teachers presumed that STEM learning has one element (science, technology, engineering, or mathematics), and 5 of 9 pre-service teachers think that STEM learning has four elements (science, technology, engineering, and mathematics). Pre-service teachers presumed that various goals of STEM learning were divided into seven subthemes: drive the innovation (2 of 9 pre-service teachers), encourage independence (1 of 9 pre-service teachers), improves creativity (2 of 9 pre-service teachers), solve the problems (1 of 9 pre-service teachers), think logically (1 of 9 pre-service teachers), competent (1 of 9 pre-service teachers), and active (1 of 9 pre-service teachers). Some examples of pre-service teacher’s statement which represent the major perspective about STEM were shown below:

… where it is related to science, technology, engineering, and mathematics which are the approaches in education where the four disciplines are integrated with each other… (RH. 2–3); … it is a learning approach that deals with the four aspects of science, technology, engineering, and mathematics… (EP.3-5); … if an education without technology that means useless and dysfunction… (SA.5-7); … so these students are required to be more creative and think critically in solving the problems that the teacher has compiled… (DSA.8-9)

| Categorization (Themes, Subthemes) | Number of Pre-service Teacher | Percentage (%) |
|-----------------------------------|------------------------------|----------------|
| STEM Role in Learning Science     |                              |                |
| 1. Method                         | 1                            | 11.11          |
| 2. Model                          | 2                            | 22.22          |

Table 1. Pre-service teacher’s perspectives about STEM
Table 2 shows the pre-service teachers’ perspective on ESD. Three themes were founded, and each theme has various subthemes. Three themes comprised of the dimension, ESD’s target, ESD’s goal.

The dimension was divided into five subthemes: social (2 of 9 pre-service teachers), environment (3 of 9 pre-service teachers), economy (2 of 9 pre-service teachers), culture (2 of 9 pre-service teachers), and education (5 of 9 pre-service teachers). Pre-service teachers presumed that ESD has a specific target, which is categorized into three subthemes: current generation (3 of 9 pre-service teachers), current and next-generation (3 of 9 pre-service teachers), and the next-generation (5 of 9 pre-service teachers). The last theme was the ESD’s goals, presumed as eight subthemes. There were: to improve students’ skills (1 of 9 pre-service teachers), sustainable development (5 of 9 pre-service teachers), drive the innovation (2 of 9 pre-service teachers), improves creativity (1 of 9 pre-service teachers), builds activeness (1 of 9 pre-service teachers), supports the next-generation (1 of 9 pre-service teachers), gives positive awareness to society (3 of 9 pre-service teachers), and produces a responsible generation (1 of 9 pre-service teachers). Some examples of pre-service teachers’ statement representing their perspective about ESD are shown below:

… from ESD itself is an education which means being able to produce a product that will help us in the next life… (BY.13-15); … ESD is an education that gives awareness to students… (SA. 84-85); … ESD also includes ecological, economic, social and cultural aspects, which support sustainable development… (RH.33-35).

Table 2. Pre-service teacher’s perspectives about ESD

| Categorization (Theme, Sub Themes) | Number of Pre-service Teacher | Percentage (%) |
|-----------------------------------|-------------------------------|----------------|
| Dimension                         |                               |                |
| 1. Social                         | 2                             | 22.22          |
| 2. Environment                    | 3                             | 33.33          |
| 3. Economy                        | 3                             | 33.33          |
| 4. Culture                        | 2                             | 22.22          |
| 5. Education                      | 5                             | 55.56          |
| ESD’s Target                      |                               |                |
| 1. Current generation             | 3                             | 33.33          |
The pre-service teachers’ perspective about the advantage of STEM and ESD was shown in Table 3. Three themes were founded and categorized into advantages for students, teachers, and society.

The advantages to the students were divided into fourteen subthemes. There were: capable in problem-solving (5 to 9 pre-service teachers), think logically (2 of 9 pre-service teachers), innovative (2 of 9 pre-service teachers), social responsibility (1 of 9 pre-service teachers), multidiscipline knowledge (1 of 9 pre-service teachers), applicative (2 of 9 pre-service teachers), independence (2 of 9 pre-service teachers), creative (1 of 9 pre-service teachers), think critically (2 of 9 pre-service teachers), improve technological skill (2 of 9 pre-service teachers), wise personality (1 of 9 pre-service teachers), think scientifically (1 of 9 pre-service teachers), competent (1 of 9 pre-service teachers), and ease of learning (1 of 9 pre-service teachers). The second subthemes presumed the advantages to teachers and were categorized into ten subthemes: make ease the learning process (2 of 9 pre-service teachers), create a comfortable learning atmosphere (1 of 9 pre-service teachers), produces students who oriented in ESD (1 of 9 pre-service teachers), more efficient teaching process (2 of 9 pre-service teachers), feel satisfied because they produce the quality students (1 of 9 pre-service teachers), capable in problem-solving (1 of 9 pre-service teachers), ingenious (1 of 9 pre-service teachers), improves knowledge (2 of 9 pre-service teachers), and applicative (2 of 9 pre-service teachers). The third, the advantage to the society was divided into eight subthemes. There were environmental awareness (2 of 9 pre-service teachers), more efficient information searching (1 of 9 pre-service teachers), improves the quality of human resources (2 of 9 pre-service teachers), repairing (preparing) next generation (1 of 9 pre-service teachers), improve building construction (1 of 9 pre-service teachers), improves social interaction (1 of 9 pre-service teachers), improve knowledge (1 of 9 pre-service teachers), and improving the skills (1 of 9 pre-service teachers). Some examples of pre-service teachers’ statement representing their perspective about the advantage of STEM implementation in the learning process to promote ESD were shown below:

… make students more skilled in solving problems… (DSA.81-82); … the experience has increased, the knowledge has increased because in ESD has only been intensified recently so they have never been able to do so, in my opinion, they are lucky because they can get new knowledge, so maybe they can manage the natural resources around them too… (EP.234-237); … more improves human resources in managing natural resources… (EP. 217)
Table 3. Pre-service teacher’s perspectives about the advantage of STEM implementation to promote ESD

| Categorization (Theme, Sub Themes) | Number of Pre-service Teacher | Percentage (%) |
|-----------------------------------|-----------------------------|----------------|
| Student                           |                            |                |
| 1. Capable to solve problem        | 5                          | 55.56          |
| 2. Think logically                 | 2                          | 22.22          |
| 3. Innovative                     | 2                          | 22.22          |
| 4. Social responsibility           | 1                          | 11.11          |
| 5. Multidisciplinary knowledge     | 1                          | 11.11          |
| 6. Applicative                    | 2                          | 22.22          |
| 7. Independence                   | 2                          | 22.22          |
| 8. Creative                       | 1                          | 11.11          |
| 9. Think critically               | 2                          | 22.22          |
| 10. Improve technological skill   | 2                          | 22.22          |
| 11. Wise personality              | 1                          | 11.11          |
| 12. Think scientifically          | 1                          | 11.11          |
| 13. Competent                     | 1                          | 11.11          |
| 14. Ease of learning              | 1                          | 11.11          |
| Teacher                           |                            |                |
| 1. Learning process is easier     | 2                          | 22.22          |
| 2. Creates a comfortable atmosphere in learning | 1 | 11.11 |
| 3. Produces students who oriented in ESD | 1 | 11.11 |
| 4. More efficient teaching process | 2 | 22.22 |
| 5. Teacher feels satisfied to produce the quality students | 1 | 11.11 |
| 6. Creative                       | 1                          | 11.11          |
| 7. Capable in problem-solving     | 1                          | 11.11          |
| 8. Ingenious                      | 1                          | 11.11          |
| 9. Improve knowledge              | 2                          | 22.22          |
| 10. Applicative                   | 2                          | 22.22          |
| Society                           |                            |                |
| 1. Environmental awareness        | 2                          | 22.22          |
| 2. Searching information is more efficient | 1 | 11.11 |
| 3. Improve human resource quality | 2                          | 22.22          |
| 4. Preparing the next-generation  | 1                          | 11.11          |
| 5. Improve building construction  | 1                          | 11.11          |
| 6. Social interaction is improving | 1                   | 11.11          |
| 7. Improve knowledge              | 1                          | 11.11          |
| 8. Improve skill                  | 1                          | 11.11          |

3.2. Discussions

This study was aimed to find out how pre-service teachers describe STEM, ESD, and the advantage of STEM implementation to ESD in the learning process. Results showed that there were various perspectives about STEM, ESD, and the advantage of its implementation. Table 1 shows that mostly pre-service teachers presumed STEM as a learning approach, based on technology, composed of 4 elements, and has a goal to teach and improve problem-solving skills. Table 2 shows that majority of pre-service teachers thought ESD as an education, to prepare for the next generation, and achieve sustainable development. Table 3 shows that pre-service teachers have perspectives about the advantage
of STEM and ESD implementation as the tool to make students to be more capable in problem-solving, improving teachers’ knowledge, to be more applicative (contextual), and build the environmental awareness.

STEM is an important thing to know as the basis for learning problems-solving. STEM integrated science, technology, engineering, and mathematics effectively to engage students in higher-order thinking and problem-solving skills [10]. STEM also has the potential to produce logical thinkers and technologically literate students [6], with lifelong learning skills [5]. The pre-service teachers should understand STEM because as the teacher candidates they have the role of the facilitators in the learning process, and thus, they have to manage four elements of STEM in learning activities effectively and efficiently.

ESD is a framework that emerges from a sustainable development idea established in Rio de Janeiro in 1992. ESD can help to develop knowledge of the economy [3], teaching and learning social [11], knowledge of the environment [8], and achieving sustainable development [12]. The results showed pre-service teachers have insufficient knowledge about STEM and ESD. There were some pre-service teachers explain the ESD as an education integrated social, economic, and education aspect, but the rest don’t mention about the social aspect, or economic aspect, or environment aspect. Most of the pre-service teachers just understand ESD as the educational program to achieve sustainable development for the next generation. These perspectives were not wrong, but incomplete. Pre-service teachers should improve their knowledge about ESD to make the transfer of knowledge to the students about ESD more effective.

STEM can be implemented in teaching and learning activities to promote ESD. STEM has the potential to make students and teachers skilled in problem-solving, higher-order thinking, environmental awareness, independence, and responsible, and also useful for society in economic, social, and environmental development which were the ESD’s goals.

4. Conclusions
The results showed many perspectives about STEM, ESD, and its advantage. Most of the pre-service teachers describe STEM as the integrated learning approach based on technology, consisted of science, technology, engineering, and mathematics which emerges problem-solving skills. ESD in the pre-service teachers’ perspective is also known to have goals to achieve sustainable development for the next generation. More than half of participates think about STEM’s advantage to promote ESD is to improve students’ problem-solving skill, improves teacher knowledge, make teachers applicative (contextual), also encourage environmental awareness in society. These perspectives were general knowledge about STEM and ESD. Pre-service teachers should improve their knowledge of STEM and ESD. The pre-service teacher should be prepared to face educational issues for the next generation. Furthermore, the socialization of STEM to promote ESD in Indonesia needs to be given massively, effectively, and efficiently, and the development of STEM learning to promote ESD must be designed depending on students’ characteristic, behavior, and culture in each country.

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