STEM Learning and its Barrier in Schools: The Case of Biology Teachers in Malang City

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Abstract. The purpose of this paper is to determine the teacher's understanding of STEM and the barriers faced by teachers in implementing STEM learning. The study was a qualitative descriptive study. Qualitative data were obtained through a questionnaire given to 15 teachers who are members of the biology teachers learning community (MGMP Biologi) in Malang City. Data analysis was carried out qualitatively based on the results of the questionnaire given to the teacher. The results showed that teachers' understanding of STEM was still low. The main barrier faced in the implementation of STEM-based learning is teacher understanding about STEM still low and students' motivation to learn STEM is less. Suggestions for increasing the intensity and quality of STEM learning in schools are held training to improve teacher skills and collaboration between schools, government, and universities to improve the quality of STEM learning.

1. Introduction
The 21st century is a century of knowledge where technology and information are developing very rapidly. In the 21st century a person is required to have several abilities in order to be able to compete both locally and globally. Greenstein (2012) explains that in the 21st century there are 3 main abilities that must be possessed namely the ability to live in a society; the ability to learn and innovate (including the ability to think critically, communicate, be creative and collaborate); and information and technology capabilities [1]. The rapid development of technology gave birth to the industrial revolution known as the Industrial Revolution 4.0. Revolution 4.0 requires people to innovate to produce new and high-quality ideas so they don't lag behind other countries [2]. Industry 4.0 is believed to be able to increase flexibility, change quality, and increase productivity [3]. This increase can occur if a country has adequate human resources and can keep up with technological developments. The Industrial Revolution 4.0 will reduce employment because there will be a lot of automation [4] so that innovative people are needed so that humans can create new jobs. To create a suitable and sustainable society in the 21st century requires preparation from an early age. Preparations can be made through teaching and learning.

Teaching and learning are the most important things in the process of developing human resources [5]. Education provides opportunities for students to learn about life [6] or develop their thinking skills [7]. Teaching and learning make humans able to improve their quality of life [8]. Education is strongly influenced by several factors, both internal and external factors [9]. Internal factors that influence learning include student health conditions, student psychological conditions, student motivation in learning, etc. External conditions that affect learning include infrastructure, environmental conditions, family, etc. The education and learning process is inseparable from the role of the teacher as an educator [10,11].

The teacher has an important role in the teaching and learning process. The teacher's role is very important because the teacher acts as a leader in learning. In the teaching and learning process the teacher can determine the approach used, the learning model used, and the method used [12]. The selection of approaches, models and learning strategies by teachers will determine the quality of learning [13,14].
As a leader in learning the teacher must have the capability in his profession [15]. Teacher's capability is very much needed so that the learning process can be maximized [16]. To improve the quality of learning, teachers can use several approaches in accordance with the progress of the age (21st century) [17]. One approach that is now widely used by various countries in the world is the STEM approach.

STEM is an acronym of the integration of science (S), technology (T), engineering (E) and mathematics (M). Although the idea of STEM education has been discussed since the 1990s in the USA, few teachers seemed to know how to operate STEM education several decades later [18]. STEM is a combination of various approaches that have been adopted from different disciplines, which involve single or multi-disciplinary contributions to one activity [19]. There are various studies that show that STEM learning can improve various aspects of learning. Research conducted by León, Núñez, & Liew (2015) shows that STEM learning can improve student self-regulation and motivation in learning. STEM can also be combined with learning models such as Project-based learning. Research conducted by Lestari & Sumarti (2018) shows that the STEM-Based Project-based Learning Model can improve the science process skills and creative thinking of elementary school students in 5th grade. STEM-based learning can also increase student literacy [22]. Based on this it is necessary to know the understanding and Barriers of teachers in implementing STEM learning.

2. Methods
The study was a qualitative descriptive study. Qualitative data were obtained through a questionnaire given to 28 teachers who are members of the biology teachers learning community (MGMP Biologi) in Malang City. Analysis of the data used is qualitative analysis with the help of The nVivo application. The purpose of this research is to find out STEM learning that has been done by the teacher and the barriers faced by the teacher in implementing STEM learning.

The questions used in this study are:
1. According to you, what is STEM?
2. What is the barrier for you to study biology with STEM?
3. How do you overcome these barriers?
4. Have you ever teach biology with STEM?

3. Results and Discussion
3.1. Teacher's Understanding of STEM
Teacher's understanding of STEM can be seen in Table 1.

| Understanding Level | Total |
|---------------------|-------|
| Definition level    | 19    |
| Explanation Level   | 9     |

The question to find out the teacher's understanding is “According to you, what is STEM?” Most of the teachers still mentioned the acronym of STEM when asked this question. An understanding of STEM is very important for teachers to have. Teachers’ lack of knowledge about STEM and the mindset of teachers who feel enough about their learning makes it a major challenge for STEM implementation [23]. An understanding of STEM will make it easier for teachers to apply STEM in their learning [24]. Teachers’ understanding of STEM can be improved through applicative training. Applicative training can be done by giving teachers time to practice directly.

Teachers' understanding of STEM is very necessary because to support STEM-based learning, integration is needed to gain adequate momentum, a conceptual framework is needed that is more than a simple definition and must include reasons, objectives, expected results, components, and how these components interact [25]. The conceptual framework can also help teachers to conduct research on the importance of teaching STEM in schools so that ways will be found on how to learn STEM in more effective ways [18].

3.2. Barriers in Implementing STEM-based Learning
The Barriers to teaching STEM-based on the results of the questionnaire are shown in Figure 1.
Figure 1. Teacher Barriers in Learning STEM in Schools, note: student (siswa) and teaching, learning (pembelajaran)

Based on Figure 1, the main barriers faced by teachers are about teaching and learning and student readiness. Learning is meant is less time required and the teacher does not know about how to implement STEM in schools. This was stated by respondent number 5:

"Butuh waktu lebih banyak"

"Need more time to implement STEM"

Respondent number 2:

"Apakah STEM dapat diterapkan pada semua KD pembelajaran?"

"Can STEM be applied to all learning material?"

The lack of learning time Barriers is most often experienced by teachers in implementing STEM learning. These Barriers can be overcome by using learning models that are compatible with STEM-based learning. Learning models that are suitable for implementing stem-based learning include inquiry [26], project-based learning [21], problem-based learning [27], etc.

The application of STEM in schools can be done through several stages. The application of STEM in learning has 3 types namely Shorthand for the STEM domains, mixed STEM Applications, and Integrated STEM. The 3 types of STEM applications can be seen in Figure 2.

Figure 2. STEM Spectrum
(Source: Nadelson & Seifert, 2017)

Based on Figure 2, the teacher can choose which type of STEM can be applied in their class. The choice of STEM type must be in accordance with the conditions in the teacher's class such as the condition of students, infrastructure, etc. The selection of STEM types must be in accordance with the conditions in the classroom so that learning can be carried out optimally. If students have mastered a
simple STEM, the teacher can improve their STEM learning to a more complex STEM model, namely Integrated STEM.

The second problem encountered by teachers in implementing STEM is that students are not interested in STEM learning. This is as said by respondent number 11:

“Minat siswa masih kurang memahami STEM secara luas bahwa belajar STEM sesungguhnya merupakan suatu cara mengatasi masalah yang akan dihadapi di masa yang akan datang ...”

"Students’ interest is still lack of understanding STEM widely that learning STEM is actually a way to overcome problems that will be faced in the future ..."

These problems are the main problems that not only occur in Indonesia but also occur in large countries such as America. Based on the Report President’s Council of Advisors on Science and Technology (2010) before eighth grade, many students have concluded that STEM is too challenging, boring, and/or not attractive so they are less interested and participate in learning. based on this it is important for teachers to provide motivation to students about the importance of learning STEM for their future lives.

3.3. Experiences of STEM Teachers' Practices in Schools

The results of the questionnaire given to teachers regarding the practice of implementing STEM can be seen in Figure 3.

![Teacher Questionnaire Results Regarding STEM Implementation](image)

**Figure 3.** Teacher Questionnaire Results Regarding STEM Implementation

Based on Figure 3, it can be seen that only a portion of teachers who have implemented STEM learning are still below 50%. Training on STEM has been conducted by the government in Malang. The few teachers who carry out STEM-based learning are caused by several barriers as explained in the previous sub-discussion. Of the 9 teachers who have never implemented STEM learning in their class, there are only 2 teachers who have observed STEM learning conducted by other teachers. In addition to students, teachers must also have the motivation to teach STEM in their classrooms [24].

Motivation to teach STEM by teachers can be improved by involving various elements of government such as school principals, supervisors, education offices, etc. Further training needs to be done so that teachers become more proficient in implementing the STEM approach in learning. The training conducted can improve teacher skills in teaching. Teacher skills have an important role in determining the quality of STEM implementation in schools [29].

4. Conclusions

Based on the results of the study showed that the application of STEM in the city of Malang still has barriers. These Barriers include the teacher's understanding of STEM is still low. This is indicated by the number of teachers who answer questions about understanding STEM with an acronym without explaining what STEEM is, how to do STEM, how to integrate STEM in learning, etc. In addition, the motivation of teachers in implementing STEM-based learning is still low, this is evidenced by only 6
out of 15 teachers who have implemented STEM-based learning in their class. In addition there are only 2 out of 9 teachers who have never carried out STEM-based learning who have seen/made observations in other classes using STEM-based learning.

To increase the intensity and quality of STEM implementation in schools, collaboration from several parties including schools, government and universities are needed. Training needs to be held so that teachers become more familiar with STEM so that teachers can prepare STEM well. Collaboration from universities needs to be done so that studies can be carried out on the implementation of STEM in accordance with its nature and how to improve the quality of STEM learning in schools.

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