Analysis of Senior High School Mathematics Teachers' Perception of The Application of STEM-Based Learning

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Abstract

STEM-based learning is a learning approach that integrates science, technology, engineering, and mathematics in a lesson so that students have critical thinking skills, and they can solve problems creatively, and consequently, students will have a selling point in the labor market. This study aims to determine the senior high school teachers' perception of the application of STEM-based learning. This study is descriptive qualitative research that describes the facts and circumstances about the senior high school teachers' perception of the application of STEM-based learning. The subjects of this study were senior high school mathematics teachers in Serang City and Serang District. The research instrument was an open questionnaire consisting of 21 questions. After being given an open questionnaire, observations and interviews were conducted. Based on the results of the analysis of the open questionnaire given, it is known that senior high school mathematics teachers still lack information about STEM-based learning. Not all teachers know about STEM-based learning, in fact there are some teachers who have just heard the term. Therefore, socialization and training are needed so that all teachers have a good understanding of STEM-based learning.

Abstrak

Pembelajaran berbasis STEM merupakan suatu pendekatan pembelajaran yang mengintegrasikan sains, teknologi, rekayasa, dan matematika dalam suatu pembelajaran yang bertujuan agar siswa memiliki keterampilan berpikir kritis dan dapat memecahkan masalah secara kreatif, sehingga mereka memiliki nilai jual di pasar tenaga kerja. Penelitian ini bertujuan untuk mengetahui persepsi guru matematika SMA mengenai penerapan pembelajaran berbasis STEM. Penelitian ini merupakan penelitian deskriptif kualitatif yang menggambarkan fakta dan keadaan sebenarnya tentang persepsi guru matematika SMA mengenai penerapan pembelajaran berbasis STEM. Subjek penelitian ini adalah guru mata pelajaran matematika SMA di Kota Serang dan Kabupaten Serang. Instrumen penelitian berupa angket terbuka yang terdiri dari 21 pertanyaan. Setelah diberikan angket terbuka kemudian dilakukan observasi serta wawancara. Berdasarkan hasil analisis terhadap angket terbuka yang diberikan, diketahui bahwa guru matematika SMA masih kekurangaan informasi mengenai pembelajaran berbasis STEM. Tidak semua guru mengetahui tentang pembelajaran berbasis STEM, bahkan masih ada guru yang baru mendengar istilah tersebut. Oleh karena itu, diperlukan sosialisasi dan pelatihan agar seluruh guru memiliki pemahaman yang baik mengenai pembelajaran berbasis STEM.

Keywords: STEM; Perception; Teachers; Mathematics.

UNNES JOURNALS

INTRODUCTION

In 1957 Soviet Union, launch the Sputnik, the incident made United States develop a curriculum to ensure sustainability as global leader. More than 50 years later, there are impulses to improve science, technology, engineering, and mathematics to produce individuals who are experts in these fields. On this basis, the term STEM (Science, Technology, Engineering and Mathematics) was first introduced by the NSF (National Science Foundation) in 1990 (Sanders, 2009). STEM aims to make students have critical thinking skills so that they can solve problems creatively and in the end the students will have a selling point in the labor market (Hom, 2014). STEM is used to prepare students and the workforce in the 21st century, to keep the economy healthy and to maintain the competitiveness of a country (Barakos et al, 2012).

The term of STEM has attracted attention from various groups at the beginning of its appearance. STEM has different meanings for different people (Basham, 2010; Hom, 2014). Botanical scientists think that eventually educators realize the importance of plants. Technologists are also excited about the emergence of the term STEM because they think it refers to a part of a watch (Suwarma et al., 2015).

STEM has received increasing attention during the last few decades, especially for the purpose of improving the quality of curriculum and learning (M. A. Honey et al., 2014). In a true sense, STEM is an acronym for Science, Technology, Engineering, and mathematics. STEM is promoted in many countries to prepare their citizens for modern and new life. STEM-based learning is expected to solve the problem of low scores on international assessments such as PISA and TIMMS (Pimthong & Williams, 2018). STEM are

believed to be important elements in 21st century programs (Ceylan & Ozdilek, 2015) which play an important role in advances in technology, medicine, agriculture, national security, economics and seek answers to many questions in in life.

STEM academic programs have visions to is to development and research of the workforce to meet the needs of local and regional industry, national security, and efforts to be competitive in the global market (Egarievwe, 2015). STEM graduates will have the skills to find solutions of problems that related to life, each STEM graduate will have global competitiveness (Suryana et al., 2018).

STEM represents a symbiotic relationship that exists between four fields (Basham & Marino, 2013), which refers to teaching and learning, of course in the fields of science, technology, engineering, and mathematics which includes activities at all levels of education from pre-school to post-doctoral, both formal and informal (Gonzales & Kuenzi, 2012). Kurup et al., (2019) also revealed that STEM education needs to start from basic education, in which teachers have an important role in carrying out an integrated approach. Science and Mathematics are considered to be at the forefront of STEM education (Hom, 2014), but engineering and technology aspects are also important.

It is inconceivable if a life without engineering and technology. These two aspects are not only based on solutions but emphasize the process and solution design. In this way, students can discover science and math in an easier way and adopt critical thinking skills that can be used in work and in education too. Students can use engineering to discover, explore, and solve problems. Meanwhile, technology, which is a part of STEM, can make it easier to understand something. Technology helps students apply what they get from the learning process using

computers and practice with professional applications such as CAM, CAD, and other applications and software (Ceylan & Ozdilek, 2015).

One of the hallmarks of the STEM class is its emphasis on design and problem solving. Problems arise in the STEM class, then students carry out research and investigation projects, which require them to use technology to collect and analyze data, design, test, find solutions and then publish the results (Groome, 2007). Students must complete low-level cognitive tasks (for example remembering facts) and gain a basic understanding of the content so that it allows students to acquire higher order thinking skills (Basham & Marino, 2013).

STEM is not a specific discipline so all teachers can participate in the planning and implementation. Teachers can discuss ideas about the content and how transdisciplinary approaches can be used to improve student understanding. To make this instruction authentic, teachers must work as a team not individually (Basham et al., 2010). Currently, learning that is carried out in schools when discussing STEM subjects is still separate, even though teaching STEM subjects that are connected to each other make STEM subjects more relevant to students and even teachers themselves, because it can increase interst, student persistence, motivation, and achievement (M. Honey et al., 2014).

Currently STEM education is not well understood by teachers. They do not understand the concept of STEM and cannot describe the meaning of STEM itself (Brown et al., 2011). Many teachers do not yet realize that STEM is more than a new name for teaching science and mathematics. They also do not understand that this is more than just the use of technology and engineering into the standard curriculum of science and mathematics

(Lantz, 2009). In addition, teachers in the STEM field still lack information about the STEM approach and the integrative benefits of the STEM approach (Becker & Park, 2011). Even when the definition of STEM education is understood, implementation can be very different and focus on different goals from one teacher to another teachers. This implies that there is not only a need for increased awareness of the definition, but also how STEM education will be implemented. Without that step, it is possible that each person may have different ideas about STEM and its application (Brown et al., 2011).

In Indonesia, the application of STEM-based learning is not yet popular. Basically, the government has made a learning concept that integrates several subjects that we often hear about thematic lessons that are implicitly like STEM-based learning (but sometimes the concept is not clear so that the implementation in the field by teachers will also differ between teachers in one school and the other school. Currently, the teaching materials used by teachers are uniform because they come from books provided by the government that refer to the 2013 curriculum, but the textbooks compiled by the government have not led to STEM-based learning (Hasanah, Wirawati, & Sari, 2020).

Therefore, policy makers in the education sector should make a clear concept of STEM education in the context of developing instructional material and its implementation in teaching practice (Kurup et al., 2019). The government and schools should consider the development of STEM education programs including matters relating to which methods and approaches are most effective for use in STEM education (Barakos et al, 2012). Based on this, an analysis is needed regarding teachers' perceptions of the application of STEM-based learning.

According to Robbins (2003) perception is a process carried out by individuals in interpreting the impressions obtained through their senses then giving meaning, Perception is a psychological response to stimuli that arise from outside that are captured by the senses of each individual (Suhita, 2017).

Everyone will provide a different perception of the environment. This difference arises due to various factors such as attitudes, interests, expectations, motives, experiences, time and so on (Tias, 2012). Therefore, before implementing a learning process, exploration and identification of teacher perceptions is needed (Dopo & Ismaniati, 2016). Researchers distributed open questionnaires to high school mathematics subject teachers in Serang City and Serang District. After collecting the data, researchers analyzed it to determine the extent to which teachers knew about STEM-based learning, their response to the application of STEM-based learning, and what teachers need to implement STEM-based learning in the classroom.

STEM-based learning aims for students to have critical thinking skills and be able to solve problems creatively, so that they have a selling point in the labor market. For this reason, teachers need to understand the correct application of STEM-based learning so that these goals can be achieved properly. Teachers who understand the application of STEM-based learning can help students to understand and know the principles, practices, and processes of producing a product or output, which is not only understood theoretically, but also useful in everyday life.

METHOD

This study is descriptive qualitative research that describes the facts and circumstances about senior high school mathematics teachers' perceptions of the application of STEM-based learning. The subjects of this study were senior high school mathematics teachers in Serang City and Serang District.

The research instrument was an open questionnaire consisting of 21 questions aimed at knowing (1) the definition of STEM based on the views of each teacher; (2) whether STEM has been implemented in the place where the teacher teaches; (3) Background on the application of STEM; (4) STEM suitability in the environment and student conditions; (5) the suitability of STEM with the applicable curriculum of the school; (6) the importance of applying STEM in mathematics learning; (7) preparations that must be made before implementing STEM; (8) how many teachers have implemented STEM; (9) linkage of STEM with other lessons; (10) the use of technology in the learning process; (11) available facilities and infrastructure to support learning; (12) STEM-based learning lesson plans; (13) Student responses to STEM-based learning; and (14) the teacher's opinion is that there is a need for training on STEM education for mathematics teachers. The questionnaire was filled out by 10 teachers from several different schools.

In addition to the questionnaire, the researcher also made expert validation sheet which was used to determine level validity of the questionnaire used in collecting data and an interview sheet to obtain more accurate and detailed answers to the answers that respondents gave in the questionnaire.

This study uses the triangulation method to meet the validity of the data, namely by comparing the data from open questionnaires, observations, and interviews. Data analysis techniques are carried out by collecting data, reducing, presenting data, and drawing conclusions.
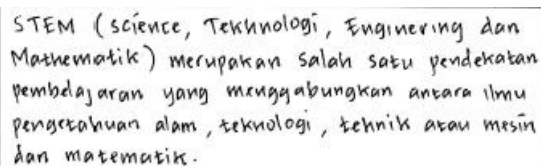
RESULT AND DICUSSION

Result

Data was collected through an open questionnaire given to high school mathematics and science teachers in Serang City and Serang District. From the 21 questions given, the researcher chose 10 questions that were most related to the research topic being discussed. the discussion of the teacher's answers from the 10 questions given are as follows:

Question 1:
What do you know about STEM-based learning?

STEM (Science, Technology, Engineering, and Mathematics) is a learning approach that integrates science, technology, engineering, and mathematics.
Figure 1. First teacher answer

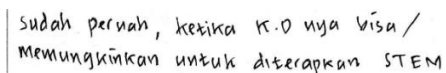I've never heard about STEM.
Figure 2. Second teacher answer

Analysis of the answers given by the teachers based on question number 1.

Not all teachers know about STEM-based learning. In fact, there are some teachers who have just heard the term from researchers. Based on the results of interviews conducted, it is known that teachers who know about STEM-based learning are teachers who have attended In House Training (IHT) which was held at SMAN 1 Ciomas which was attended by 7 schools including SMAN 1 Pabuaran, SMAN 1 Padarincang, SMA Bina Mahmud, SMA 1 Baros. The speaker comes from SMAN 4 Bandung City. However, some schools have not received any training on STEM-

based learning, so the term is still unfamiliar. Teachers who have not received training on STEM-based learning expect socialization and training about how to apply STEM in the learning process.

Question 2:
Have you implemented STEM-based learning in your classes?

Yes, I have. I implement it when the basic competencies of the subject allow for STEM-based learning applications.
Figure 3. First teacher answer
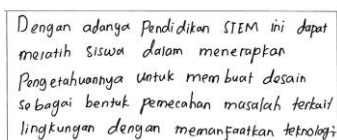

I haven't applied STEM-based learning in my class.
Figure 4. Second teacher answer

Analysis of the answers given by the teachers question number 2.

Most of the teachers answer that they have not implemented STEM-based learning in their classes. Some teachers answer and claim they implemented STEM when basic competencies of the subject allow the application of STEM-based learning, but they cannot describe what basic competencies can STEM-based learning be applied to. Some of them said that they have implemented STEM-based learning in their classes by using *Microsoft PowerPoint* as technology to explain three-dimensional material.

Question 3:
What are your reasons for applying STEM-based learning in your classes?

The application of STEM-based learning can train students how to apply their knowledge to make designs in order to solve problems using technology.
Figure 5. First teacher answer

Belum diterapkan

I haven't applied STEM-based learning in my class.
Figure 6. Second teacher answer

Analysis of the answers given by the teachers question number 3.

Teachers who have not implemented STEM in their classes cannot provide explanations because they have never implemented it. Only few teachers can give reasons why they implement STEM-based learning in their classes. A teacher explained that the application of STEM-based learning can train students how to apply their knowledge, to make designs to solve problems using technology. In addition, some others said that the application of STEM-based learning can improve students' and teachers' ability to utilize technology, which it is a part of STEM-based learning.

Question 4:
Do you think the application of STEM-based learning is suitable for your classes?

COCOK, karena melatih 4C peserta didik

Yes, because STEM-based learning can train students' 4C abilities.
Figure 7. First teacher answer

Belum diterapkan

I haven't applied STEM-based learning in my class.
Figure 8. Second teacher answer

Analysis of the answers given by the teachers question number 4.

Teachers who have not implemented STEM-based learning cannot provide information on whether it is suitable to be applied or not, because they do not understand well what STEM-based learning is and whether it will suit the conditions of the students in their school. Meanwhile, teachers who have received training related to the application of STEM-based

learning, especially in mathematics, gave the opinion that STEM is suitable to be applied because it can train 4C students including (1) Critical thinking, which is an ability to understand complex problems and then the problem can be solved by connecting information , knowledge, and experience already owned; (2) Communication is an activity of transferring information both orally and in writing through a medium so that it can be well received and understood by the recipient of the message; (3) Collaboration is the ability to work together in completing the tasks and problems presented; (4) Creativity is the ability to think that is able to look at a problem from various different perspectives so that the mind will be more open and can easily solve the problems at hand.

Question 5:
Could you explain the importance of the application of STEM-based learning in Mathematics?

untuk meningkatkan kemampuan problem solving matematis siswa, kemampuan pemahaman konsep dan representasi matematis siswa.

To improve students' problem-solving skills, understanding of concepts, and representational ability in mathematics.
Figure 9. First teacher answer

Belum tau jadi belum bisa mengelaskan

I don't know yet, so I could not explain.
Figure 10. Second teacher answer

Analysis of the answers given by the teachers question number 5.

Most of the teachers do not understand why STEM-based learning is important to implement. This is very reasonable because, how can we understand the importance of STEM-based learning if the definition itself is not known by the teachers. However, there are teachers who think that STEM-based learning is important to be applied to mathematics

because learning mathematics with STEM can improve problem solving abilities, the ability to understand concepts and mathematical representations.

Question 6:
What should you do to implement STEM-based learning in mathematics?

banyak hal yang harus dipersiapkan :
-. kesiapan siswa
-. alat dan bahan
-. analisis K.D yang bisa digunakan STEM
-. RPP berbasis STEM

Many things that should be prepared:
- Students' readiness
- Tools and Materials
- Analysis of basic competencies that suitable for the application of STEM-based learning
- Lesson Plan of STEM-based learning

Figure 11. First teacher answer

Belum tau jadi belum bisa menjelaskan

I don't know yet, so I could not explain.
Figure 12. Second teacher answer.

Analysis of the answers given by the teachers question number 6.

According to the teachers, many things must be prepared before implementing STEM in mathematics learning, including the following: (1) Students' readiness, namely introducing students to what STEM is and explaining the benefits of implementing STEM-based learning in mathematics; (2) The tools and materials used in the learning process; (3) Analysis of basic competencies that suitable for the application of STEM-based learning; (4) Basic knowledge of science material which will be integrated with mathematics; (5) STEM-based.

Question 7:
In your opinion, are there any mathematics learning materials related to science lessons?

ada, Biologi , Kimia , Fisika,
Karena pelajaran-pelajaran tersebut saling berkaitan

Yes, there are, such as biology, chemistry, and physics. Those lessons are related to each other.
Figure 13. First teacher answer

Ada
terutama Fisika dan kimia

Yes, there are, especially physics and chemistry.
Figure 14. Second teacher answer.

Analysis of the answers given by the teachers question number 7.

Based on the analysis carried out on the answers given, it was found that the teachers cannot explain what material had to do with science lessons. The answer given by the teacher is not about the material but only states that biology, chemistry, physics are related to mathematics so that teachers need basic competency analysis to find out what subjects in mathematics can be applied STEM-based learning.

Question 8:
How do you use certain technologies in the learning process?

Memanfaatkan LCD, video pembelajaran, dll.

I use LCD monitor, learning videos, and others.
Figure 15. First teacher answer

Dorongan untuk itu ada,
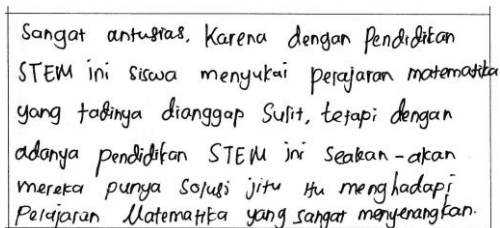namun pelaksanaan masih jarang

I rarely use technology in my class.
Figure 16. Second teacher answer

Analysis of the answers given by the teachers question number 8.

Based on the results of the analysis of the teacher's answers, it was found that not all teachers used technology as a means of assisting the learning process. According to the results of interviews conducted, the intention and urge to use certain technologies in explaining mathematics material already exists, but in practice it is still difficult to do. Some teachers who claim to

have used technology carry out learning by giving assignments to students on a certain subject, then students are given assignments to present these assignments assisted with power points. The use of certain mathematical applications such as *geogebra* or *sketchpad* has not been applied because the teacher himself has not mastered the use of these mathematical applications.
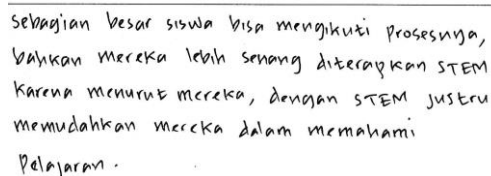
Question 9:
How do students respond to STEM-based learning in mathematics?

The students are very enthusiastic about STEM-based learning. They become fond of math, which they previously thought was difficult. STEM-based learning makes the students feel they have the right solution and solve math problems with enjoyment.
Figure 17. First teacher answer

Most students can follow the learning process and feel more fun. According to them, STEM-based learning makes it easier for them to understand the lesson.
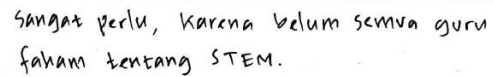*Figure 18. Second teacher answer.*

Analysis of the answers given by the teachers question number 9.

Teachers who have already implemented STEM-based learning explained that most students were able to follow the learning process well even after the implementation of STEM-based learning, many students liked learning mathematics, where learning mathematics was easier to

understand as if they found accurate tricks to deal with difficult math lessons. At first it was difficult to understand and learn.

Question 10:
In your opinion, do math teachers need training and socialization on STEM-based learning?

It is very needed because many teachers do not understand STEM-based learning.
Figure 19. First teacher answer

It is very needed.
Figure 20. Second teacher answer.

Analysis of the answers given by the teachers question number 10.

All teachers who were given an open questionnaire and interviewed said that it is necessary to hold training and socialization about STEM-based learning because not all understand about STEM-based learning, even there are still many teachers who do not know at all about STEM-based learning.

Discussion

Based on the answers collected through open questionnaires, some information is known including: (1) There are still many teachers who have never heard of the term STEM (as revealed by teacher 2 for question 1), to obtain further information, the researchers conducted interviews to confirm why many teachers still don't know the term STEM. The teacher explained that until now there had been no socialization regarding STEM-based learning, the last socialization that teachers got was only about the 2013 curriculum. There were also teachers who said that it was possible that socialization about STEM-based learning had been

obtained by one of the teachers where he taught, but usually Those who attended the socialization were only teacher representatives and the results had not been conveyed to other teachers so that the information was not yet known by all teachers. STEM-based learning that was felt was foreign and something new was not only revealed by teachers in the Serang City and Serang District of Banten Province, because this was also felt by teachers in other areas. Izzati et al., (2019) revealed that although STEM is in line and fits the 2013 curriculum, there are still many teachers and students of the teaching and education faculties in Riau Islands Province who admit that STEM is still somewhat foreign. So that it requires attention from the government to introduce STEM as an innovation in learning.

(2) The application of STEM-based learning has certainly not been applied in places where teachers do not know and understand about STEM-based learning while for teachers who have received socialization about STEM-based learning, they have tried to apply it in classroom learning. When researchers confirm what learning is like and whether there is coordination with other lesson teachers. The teachers replied that they were implementing STEM-based learning by making teaching materials on *Microsoft Power-Points* and then showing them to the students. The teacher considers that STEM-based learning is sufficient to do by adding technological aspects to the learning carried out because this aspect is one of the elements in STEM-based learning. Teachers' assumptions regarding STEM-based learning that simply adding technological aspects to learning are wrong and many of these mistakes are still made by teachers who feel they have implemented STEM-based learning. This is in line with the opinion expressed by Lantz (2009) that STEM is more than just the use of

technology in the learning that is carried out. Brown et al., (2011) also added that currently STEM education is not well understood by teachers. They do not understand the concept of STEM and cannot describe the meaning of STEM itself. Many teachers do not realize that STEM education is more than a new name in teaching science and mathematics (Lantz, 2009). Teachers in the STEM field still lack information about the STEM approach and the integrative benefits of the STEM approach (Becker & Park, 2011). Even when the definition of STEM education is understood, the implementation and focused goals can be different (Brown et al., 2011). This implies that there is a need for a more detailed presentation and provision of information to teachers that can be carried out in the form of seminars or training to equalize perceptions related to STEM (as expressed by the teachers in the answer to question 7).

(3) Many things must be prepared, such as analyzing, which essential competencies can be used to apply STEM-based learning, making STEM-based learning plans, consulting with teachers of other subjects such as science (including physics, chemistry and biology teachers) and ICT / computer teachers, preparing teaching aids, preparing tools and materials to be used in learning, monitoring student readiness before the learning process is carried out and much more that the teacher must prepare carefully before implementing STEM-based learning. This is reinforced by the statement expressed by Sari & Juandi (2021) that proper and adequate preparation of teaching materials is needed because currently not many educators and researchers have formulated and made STEM-based learning materials, so it is quite difficult to find STEM-based learning materials.

Looking at the opinions expressed by the teacher, it can be understood that

STEM-based learning needs to be immediately applied to mathematics learning. This is because STEM-based learning has a positive effect on student achievement and makes it easier for students to understand the real application of mathematics (Becker & Park, 2011). The real-world contexts is the central of STEM education because it is important goal to prepare individuals to face complex real-world problems that require the application of skills and knowledge from multiple disciplines (Maass et al., 2019). Zamista (2018) states that STEM-based learning is a form of innovation that is most suitable to answer the challenges that students must face in the future. STEM-based learning provides the widest possible opportunity for students to apply the concepts of science and mathematics which initially only seemed like learning that was full of theory, so that learning felt more meaningful. Through STEM-based learning, the concepts of science and mathematics presented can also be integrated with technological and engineering aspects to provide a memorable learning experience for students.

This research is limited to the perception of mathematics teachers in Serang City and Serang District, researchers have not investigated the perceptions of science teachers or teachers who teach ICT where these subjects are still related to STEM so that if there are other researchers who want to research things that are in line with this research, they should conduct interviews and distribute questionnaires to teachers of other subjects.

CONCLUSSION

STEM-based learning is a learning approach that integrates science, technology, engineering, and mathematics in a lesson. STEM-based learning is believed to be one of the important elements in educational programs in the 21st century. STEM-based learning represents a symbiotic relationship that exists between the four fields that refer to teaching and learning in the fields of science, technology, engineering, and mathematics. Currently STEM-based learning is not well understood by teachers. They do not understand the concept of STEM-based learning and cannot describe the meaning of STEM-based learning. Based on the results of the analysis of the open questionnaire given, it was found that mathematics teachers still lacked information about STEM-based learning. Not all teachers know about STEM-based learning. In fact, there are still many teachers who have just heard the term. Teachers who know about STEM-based learning are teachers who have attended In House Training (IHT). However, teachers who have attended training also do not understand well what basic competencies can be applied to STEM-based learning. Therefore, socialization and training are needed so that all teachers can understand STEM-based learning well. After that, the government is expected to provide support and formulate appropriate STEM-based learning for teachers to be implemented based on the understanding possessed by the teachers.

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