Attitude, Knowledge, and Application of STEM Owned by Science Teachers

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Abstract. Providing STEM (Science Technology Engineering Mathematics) education and apply it in learning is influenced by teacher’s knowledge and attitude towards The purpose of this study is to determine the teachers and lecturers’ attitudes, knowledge, and application of STEM education. Data were collected from the responds of science lecturers and teacher toward a set of STEM instuments. The results point out that respondents strongly agreed to apply STEM education in learning and are sure that students would get added value when applying STEM education. Regarding aspect of knowledge, more than 50% of the respondents have adequate knowledge of the term STEM although more than 50% of the respondents do not grasp the idea of weaknesses and advantages of implementing integrated STEM. Furthermore, 76.2% of respondents tried to implement integrated STEM when teaching with a percentage between 26% -75%. The application of integrated STEM involving the discipline of engineering has a lower percentage of application than integration with other disciplines. The findings also report that obstacles to the implementation of integrated STEM are the ability to apply the mathematics concepts, technological tools available, the duration of learning time, and the process of connecting between disciplines in STEM. This research implies that there is a need to increase the understanding the interrelationships between aspects of STEM, and need to develop STEM-based learning models to support the application of integrated STEM in Science learning.

1. Introduction

Industrial Revolution 4.0 has a massive impact on the development of society. Developments that occur in the community in terms of science and technology require students to be better prepared to deal with it. Students need to be prepared because in the future human resources of school age do not become a burden of development but can be a major factor in national development. The preparation that students need to do is that students are allowed to experience learning in a multidisciplinary context [1]. Students can be prepared to face current developments in a multidisciplinary context through STEM Education.

STEM education begins with a learning program prepared by the United States Government to create high school and tertiary graduates to be able to compete globally [2]. STEM education program, which originated in the United States [2] [3], then spread to several other countries such as Australia, India, Malaysia, and Turkey [3][4][5]. Although STEM education initially developed in western countries, some developing countries experienced an increase in the use of STEM [4]. The application of STEM education as a form of preparation for facing global competition, especially in the era of industrial revolution 4.0, is carried out by both advanced countries and developing countries.
STEM is an integration of Science (S), Technology (T), Engineering (E), Mathematics (M). STEM education is a unique approach in the context of the interrelationships between Science, Technology, Engineering, and Mathematics [6][7]. STEM education as an attempt to combine all or two of the STEM disciplines in certain units (e.g. chapters or concepts) based on interdisciplinary relationships and real-world problems [8]. STEM education has the characteristics of student-centered learning. Thus, STEM education aims to prepare students to face the development of science and technology, be ready in the world of work, and be able to solve problems.

The success of STEM Education is influenced by how STEM Education is implemented within the framework of the learning model. Besides, Teachers’ ability in STEM Education also determines the success of STEM education. Teachers are one of the main factors in Education, as well as STEM Education. Learning design that connects interdisciplinary in STEM Education is a complex activity. Those complex activities require teachers can make students understand how to implement STEM in real-world problems [9]. The teaching role in STEM learning can be viewed from aspects of knowledge, attitudes, and how to implement integrated STEM in learning.

There are several notions of attitude. The definition of attitude as an assessment of an object that can be stated with certain conditions such as pleasant or unpleasant, good or bad [10]. While another researcher state that attitudes are feelings towards a habit or object that is raised through negative, positive, or neutral expressions [11]. Attitudes also show mental and emotional entities that characterize one's actions and thoughts [12]. This study defines the attitude towards STEM as the teacher's level of curiosity towards STEM Education, the teacher's agreement to apply the integration of STEM during learning, and what the teacher thinks about STEM Education.

The next aspect surveyed in this study is knowledge about STEM. Knowledge is a testing situation that emphasizes the process of remembering, either by way of recognition or recalling an idea, object, or phenomenon [13]. Knowledge can be defined as one's familiarity and awareness of ideas or objects and the range of one's thoughts on certain information [14]. Based on information processing theory, knowledge comes from information obtained from the environment is then through storing and encoding processes stored in long term memory [15]. Knowledge stored in Long term memory can be divided into declarative knowledge, procedural knowledge, conditional knowledge [16]. In this study, STEM knowledge is all the information that the teacher has about the characteristics of STEM, the advantages, and the disadvantage of STEM and the integration between disciplines in STEM.

Application is an action involving an idea or procedure in an activity to achieve a certain goal. The application of STEM in this study means the efforts made by Teachers during learning to involve students in integrated STEM activities. Few teachers know how to apply STEM education. Although STEM education has been tried to be adapted in several countries, the percentage of teachers who know how to apply in learning is still small [9].

Science as an aspect of STEM is an important discipline for the development of society in science and technology. Science as a basic science includes physics, biology, and chemistry. Technological sophistication originates from Science which collaborates with mathematics and is applied through engineering principles. At the education level, Science teachers become one of the important aspects of the implementation of STEM education. Then, it is necessary to research attitudes, knowledge, and application of STEM in learning by the Science teacher. Research on integrated STEM can provide information to those interested in STEM education to identify shortcomings, barriers, and design the implementation of STEM Education that is suitable for its purpose.

2. Method
This is a survey research conducted in June 2019 and July 2019. The survey conducted focused on the attitudes, knowledge, and application of STEM by Science teachers. Teachers of Science here are teachers and lecturers of Science, especially Physics, Biology, and Science (junior high school level). The respondents are 21 people consisting of Lecturers and Teachers with teaching experience between 5 years and 10 years. Definitions of terms for STEM attitudes, STEM knowledge, and STEM applications have been mentioned in the introduction. The definition of the term research focus is
adjusted to the instrument used. The instruments used are the results of adaptations of Attitude, Knowledge, and Application of STEM instruments [17]. The instrument adaptation is to adjust the subject matter of the science teacher alone to become a Physics, Biology, and Natural Sciences Lecturer and Teacher. The instrument consists of 30 statements, 2 closed-ended questions, and 2 open-ended questions. Attitude, Knowledge, and Application of STEM instruments are valid and reliable [17]. The data collection process is done online using Google Form. Data analysis was done by calculating the percentage of each response for each item statement and question.

3. Result and Discussion
This research produced data on the attitudes, knowledge, and application of STEM by Science teacher. Besides, there are data on the difficulties and obstacles that will be faced by the teacher when implementing the STEM Education approach in learning and the opinion of the teacher regarding the integrated STEM approach.

3.1. Attitude toward STEM
Attitudes toward STEM were measured using 3 statements and teachers were asked to determine the level of agreement/disagreement. Statement 1 about the agreement to apply STEM in learning, statement 2 about the teacher's belief that integrated STEM will provide added value to students, and statement 3 concerning the curiosity of the teacher how to apply STEM in learning well. The results of a survey of attitudes toward STEM are shown in Figure 1. Figure 1 shows more than 95% of respondents gave a positive response ("agree" and "strongly agree") for each statement. This result shows that the respondents strongly agreed to apply the STEM education in learning and sure that students would get added value when applying for STEM education. Furthermore, respondents are very interested in knowing more about STEM education and its application.

![Figure 1](image)

**Figure 1.** The response of Teacher about Attitude toward STEM (Att1: statement 1 about attitude; Att2: statement 2 about attitude; Att3: statement 3 about attitude)

The teacher's attitude towards STEM education influences the implementation of integrated STEM in learning. The teacher's attitude towards an object or idea can be transferred to students [18]. The teacher's negative attitude towards STEM education tends to make teachers reluctant to teach with the integrated STEM approach [19]. The teacher's positive attitude towards STEM education will influence students' attitudes as well [20]. This study shows that teachers have a positive attitude towards STEM. A positive attitude towards STEM should be the initial capital to increase knowledge about STEM education and apply it in learning.

3.2. Knowledge about STEM
There are 4 statements to find out the STEM knowledge that the teacher has. Four statements about STEM knowledge consist of statement 1 about the familiarity of the term STEM, statement 2 concerning the nature of STEM in education, statement 3 is about awareness of the weaknesses and advantages of integrated STEM, and statement 4 about interdisciplinary integration in STEM. The survey results regarding STEM knowledge are shown in Figure 2. As many as 90.4% of respondents knew the term STEM. As many as 52.4% of respondents are aware that STEM is not a teaching method. The majority of respondents (76.2%) also believe that integrated STEM integrates at least 2 disciplines. However, only 23.8% of respondents had enough knowledge about the weaknesses and advantages of integrated STEM. These results indicate that respondents have enough STEM knowledge and need to increase knowledge about the disadvantages and advantages of implementing integrated STEM in learning.

![Figure 2](image.png)

**Figure 2.** The response of Teacher about Knowledge of STEM (Kn1: statement 1 about knowledge; Kn2: statement 2 about knowledge; Kn3: statement 3 about knowledge; Kn4: statement 4 about knowledge)

Teachers have an important role to play in preparing learners to face advances in technology and science that occur in society. Teacher preparation in STEM education is an important factor [21]. One of the preparations for teachers in STEM education is to increase understanding of how interdisciplinary is integrated in STEM. Integrated STEM involves at least two disciplines in STEM [6]. The same idea was proposed, that is integrated STEM integrates some or all of the disciplines in STEM [8]. Teachers also need to have pedagogical content knowledge besides content knowledge to support the professional competence of the teacher [16]. Knowledge is needed to create a strong basis for educational decisions and policies [22].

Misunderstanding about integrated STEM can occur when applying it in learning. Misunderstanding about integrated STEM for example only focuses on the development of science and mathematics [2], integration with technology and engineering is still minimal [23], does not teach high-order thinking skills [23], and focuses only in one discipline that is teachers’ background [6]. Misunderstanding about STEM experienced by the teacher is likely to occur since the teacher is still a prospective teacher. The prospective teacher has a misunderstanding about STEM [16][24]. Thus, in the context of STEM education, lecturers play a role in preparing a prospective teacher to face the development of technology and science in society and provide appropriate knowledge about STEM.

### 3.3. Application of STEM

Integrated STEM integrates at least 2 STEM disciplines in learning. The items in Application STEM must accommodate the number of possible STEM integration, namely the integration of 2 disciplines, 3 disciplines and 4 disciplines. The number of possible STEM integration is 7 items. Each item can have 3 to 4 statements. The survey results on STEM implementation are shown in Table 1.
Table 1. The response of teacher about the application of STEM

| Item                                      | No.         | Very Agree (%) | Agree (%) | Neutral (%) | Disagree (%) | Very Disagree (%) |
|-------------------------------------------|-------------|----------------|-----------|-------------|--------------|-------------------|
| Application of Science-Technology (Ap-ST) | Ap-ST1      | 23.8           | 47.6      | 23.8        | 4.8          | 0                 |
|                                           | Ap-ST2      | 4.8            | 66.7      | 19          | 9.5          | 0                 |
|                                           | Ap-ST3      | 9.5            | 66.7      | 4.8         | 19           | 0                 |
|                                           | Ap-ST4      | 4.8            | 76.2      | 14.3        | 4.8          | 0                 |
| Application of Science-Engineering (Ap-SE)| Ap-SE1      | 28.6           | 61.9      | 9.5         | 0            | 0                 |
|                                           | Ap-SE2      | 4.8            | 61.9      | 28.6        | 4.8          | 0                 |
|                                           | Ap-SE3      | 4.8            | 71.4      | 23.8        | 0            | 0                 |
| Application of Science-Mathematic (Ap-SM)| Ap-SM1      | 4.8            | 76.2      | 19          | 0            | 0                 |
|                                           | Ap-SM2      | 9.5            | 71.4      | 19          | 0            | 0                 |
|                                           | Ap-SM3      | 14.3           | 71.4      | 14.3        | 0            | 0                 |
| Application of Science-Technology-Engineering (Ap-STE) | Ap-STE1 | 9.5 | 52.4 | 28.6 | 9.5 | 0 |
|                                           | Ap-STE2     | 0              | 66.7      | 23.8        | 9.5          | 0                 |
|                                           | Ap-STE3     | 4.8            | 61.9      | 33.3        | 0            | 0                 |
| Application of Science-Technology-Mathematic (Ap-STM) | Ap-STM1 | 14.3 | 71.4 | 9.5 | 4.8 | 0 |
|                                           | Ap-STM2     | 9.5            | 66.7      | 23.8        | 0            | 0                 |
|                                           | Ap-STM3     | 19             | 57.1      | 14.3        | 9.5          | 0                 |
| Application of Science-Engineering-Mathematic (Ap-SEM) | Ap-SEM1 | 19 | 52.4 | 19 | 9.5 | 0 |
|                                           | Ap-SEM2     | 0              | 42.9      | 42.9        | 14.3         | 0                 |
|                                           | Ap-SEM3     | 4.8            | 57.1      | 38.1        | 0            | 0                 |
| Application of Science-Technology-Engineering-Mathematic (Ap-STEM) | Ap-STEM1 | 4.8 | 52.4 | 42.9 | 0 | 0 |
|                                           | Ap-STEM2    | 4.8            | 71.4      | 23.8        | 0            | 0                 |
|                                           | Ap-STEM3    | 9.5            | 52.4      | 33.3        | 4.8          | 0                 |
|                                           | Ap-STEM4    | 4.8            | 57.1      | 33.3        | 4.8          | 0                 |

The application of Science-Technology integration presents a statement about the use of electronic equipment and ready-to-use technology when teaching science by teachers or lecturers, the activity of students using simple technology or using certain procedures to make products, and use the internet by students. More than 60% of respondents gave a positive response ("agree" and "strongly agree") for each statement in item science-technology applications. Average of 9.5% of respondents gave a negative response ("disagree") for items of science-technology applications. The highest percentage of negative responses to statement 3 is the use of the internet by students. Based on open-ended questions, teachers confirm that there is no internet at some school and school policy for restrictions on carrying mobile phones. As many as 9.5% of respondents gave negative responses to statements related to the activity of students making a product. This shows that there are teachers who have not been oriented to the application of concepts to create a product.

The application of the Science-Mathematic integration presents a statement about the presentation of data on science practicum in the form of quantitative data, the use of simple statistics for data analysis, and statements about the use way-of-thinking mathematically to decision-making. The application of the integrated STEM type of Science-Mathematic integration has zero negative responses. Except for the type of Science-Mathematic integration, there must always be a negative response to other item’s statement. This shows that teachers and lecturers in the natural sciences are familiar with the use of mathematics in their teaching. As a science teacher and lecturer, especially Physics, don't be too stressed...
on mathematical operations but forget the essence of the physics concept that is represented mathematically. This effect on students focusing more on mathematical operations than physics concept [25]. Focus can mean that students give more time to understand mathematical operations because they have difficulties in mathematical aspects. This was revealed from the results of the open-ended questions at the end of the instrument.

The application of STEM integration involving Technology and Engineering disciplines has a negative response and more neutral responses than the neutral response to the integration of Science-Mathematics. The integration of Engineering and Technology is still minimal [24]. However, in recent years there have been efforts to try to integrate Engineering and Technology in STEM learning for example through engineering design [26][27], utilizing learning software [28], and implementing integrated project-based and STEM Teaching [29].

3.4. Application of STEM and the Difficulties Faced

Based on the survey results on the application of integrated STEM, the majority of respondents gave a positive response. The aspect of application integrated STEM was followed up by asking questions about how much teacher and lecturer teach using integrated STEM. The results are shown in Table 2. Based on Table 2, there are 76.2% of respondents tried to implement integrated STEM when teaching with a percentage between 26% - 75% and 76.2% of respondents tried to implement integrated STEM when teaching with a percentage between 26% - 75% at each semester. Although teachers who have sufficient knowledge about the weaknesses and benefits of integrated STEM only 23.8%, most of the respondents have implemented integrated STEM in learning. Teachers and lecturers have to know that not all content can be related to technology and engineering that exist today, for example, the content of mathematics and physics that more focus on theoretical [6]. The application of learning approaches can vary depending on the material. Variations in learning approaches are needed and useful so students are not bored.

Table 2. Response about estimated time to teach using integrated STEM

| Questions                                                                 | <25% | 26%-50% | 51%-75% | 76%-100% |
|---------------------------------------------------------------------------|------|---------|---------|----------|
| In general, what percentage of you teach using technology tools, designing technology or designing certain concepts with students and analyzing mathematically? on science learning in the classroom. | 9.5  | 23.8    | 52.4    | 14.3     |
| In general, what percentage of you integrate the mathematical, technological and engineering approaches in teaching science in the classroom each semester? | 9.5  | 28.6    | 47.6    | 14.3     |

In the final section of the survey, respondents were asked to answer 2 open-ended questions about opinions on the application of integrated STEM and the difficulties that will be faced when implementing integrated STEM. Opinions about the implementation of integrated STEM can be categorized into 3 categories, those are STEM education strengthens science in knowledge point of view and usefulness point of view, STEM education prepares students to face the 21st century and industrial revolution 4.0, and STEM education is difficult to implement and requires more ability to understand STEM. Meanwhile, opinions about the difficulties that will be faced when applying integrated STEM can be categorized into 4 categories, those are the problem of learning time, facilities that support STEM education, the ability of teachers to integrate STEM, and the ability of students in mathematics.

The application of integrated STEM not only teaches each STEM discipline together. The focus in the integration of S-T-E-M in learning is on the core contents of each discipline and interdisciplinary processes [7, 30]. The implementation of integrated STEM must make the link between S-T-E-M clear
and relate to real-world problems [6, 31]. The application of STEM education increased in various countries but not many knew about the method or approach to the application of STEM education instruction [9].

4. Conclusion
This research was conducted to know the attitudes, knowledge, and application of STEM in learning Science by teachers and lecturers. Based on data analysis and discussion, this study concludes that the majority of teachers and lecturers of Science have a positive attitude towards STEM education, have sufficient knowledge regarding the term STEM but do not have sufficient knowledge about the weaknesses and advantages of applying STEM education. Conclusions related to the application of STEM education are teachers and lecturers of Science applying STEM through the integration of Mathematics-Science, but integration involving engineering and technology is minimal. Science teachers and lecturers give the opinion that learning time, facilities that support STEM education, the ability of teachers to integrate STEM, and the ability of students in terms of mathematics are the difficulties that will be faced when applying integrated STEM. Teachers and lecturers of Science have the opinion that STEM education can strengthen science from a knowledge point of view and usefulness point of view, prepares students to compete and face technological and scientific developments in society, and need more abilities to integrate STEM because it will be more difficult to implement. The implication of this research is that there is a need to increase the understanding of teachers and lecturers about STEM education, especially the weaknesses and advantages of using STEM, increasing understanding of the interrelationships between aspects of discipline in STEM, and need to develop STEM-based learning models to support the application of integrated STEM in Science learning.

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