Journal for the Education of Gifted Young Scientists, 8(1), 17-31, March 2020
e-ISSN: 2149- 360X
http://jegys.org

**Research Article**

# Indonesian Science Teachers' Views on Attitude, Knowledge, and Application of STEM

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**Received:** 14 November 2019 **Revised:** 14 January 2020 **Accepted:** 29 January 2020

**Abstract**

This study aims to describe Indonesian science teachers' views on STEM attitude, STEM knowledge, and STEM application. The survey method was used in this study. Ninety-three Indonesian science teachers at junior high schools in Indonesia from four of 11 provinces with the largest number teachers such as Lampung, Banten, Jawa Tengah, and Jawa Timur were surveyed. The instrument in this study consisted of 30 items. The quantitative analysis was performed to address the level of three domains such as STEM attitude, STEM knowledge, and STEM application. The results showed that Indonesian science teachers' views are very good on STEM attitude ($\bar{X}$=4.68), moderate-level category on STEM application ($\bar{X}$=3.99), and low-level category on STEM knowledge ($\bar{X}$=3.72). It can be concluded that Indonesian science teachers believe that they have very good STEM attitude, moderate-level category on STEM application, and low-level category on STEM knowledge. These findings recommended to science teachers or science educators in Indonesia to promote STEM Education in the national curriculum especially in science subject to improve STEM attitude, STEM knowledge, and STEM application of Indonesian science teachers.

**Keywords:**

Indonesian science teachers, STEM attitude, STEM knowledge, STEM application

## To cite this article:

Parmin, P., A. Saregar, UA, Deta, RAZ, El Islami. (2020). Indonesian Science Teachers' Views on Attitude, Knowledge, and Application of STEM. *Journal for the Education of Gifted Young Scientists, 8*(1), 17-31. DOI: http://dx.doi.org/10.17478/jegys.647070

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## Introduction

Indonesia is one of many countries which interested in STEM Education. STEM Education in Indonesia is very new and since year 2019 many institutions in Indonesia start to focus on STEM Education. It can be indicated by many Indonesian researchers start to conduct the researchs on STEM Education both national and international collaboration such as MII-STEM (https://miistem.org/). Beside that, many conferences and workshops in Indonesia focus on STEM Education as their themes such as ICoSTEM-Ed 2019 (http://istemhouse.fkip.unej.ac.id/international-conference-of-science-technology-engineering-and-mathematics-education/). However, the research publications about STEM Education on Indonesia context are still few and it needs to conduct, many previous studies on Indonesia context only focus on developing science education (Nuangchalerm and El Islami, 2018a; 2018b; El Islami et al., 2018; Parmin et al., 2019, Sagala et al., 2019, Mnguni et al., in Press). It is thought that increasing the studies in this field will support STEM education in Indonesia.

The use of the Integrated STEM approach in science learning is not only a necessity but has become a demand because of the harsh competition in preparing competitive graduates. Students are prepared to have competitiveness with the applicable skills of applying science through science learning. Learning science from an early age is recommended so that the students can create jobs according to the occupied field. Both future science learning orientations can be achieved by applying approaches that are also future-oriented. Smith, & Lindsay (2016); Isozaki, (2018); & Tan, (2018) stated that teachers who have a vision of the future can create oriented learning to prepare highly competitive students. Teachers' STEM knowledge is an absolute requirement to create a future-oriented learning environment. If it is too late to respond to the development of science and technology through learning, it is feared that it will have a systemic impact on Indonesia because it will become a country with technological dependence from other countries. So we need to conduct the preliminary study to obtain the data on the science teachers' readiness to apply the approach.

STEM knowledge is needed by science teachers because of the need to present science in an integrated way. Broad insight is not limited to science as knowledge but also to its application so that the right strategy is needed in learning at school. The selection of the right strategy requires knowledge of the various strategies that must be chosen. González (2012); Li, et al. (2018); &Tharayil et al. (2018) stated that the accuracy of choosing a learning strategy is determined by how deep and broad the insight about the choice of various existing learning strategies. The integrated STEM approach is more easily explained through technology in society. This learning is oriented on producing products so that the designing skill could be made as one of the measured indicators. Apedoe & Schunn (2013); Williams et al.

(2018) the success of science learning can be known from the ability to use tools so that they can develop their works as a result of applying the concepts. Product design skills require mathematical knowledge. Pincock et al (2012) & Hwang et al. (2018) stated Mathematics as a basic knowledge of science, is used to understand natural phenomena and phenomena. Integrated STEM approach as an appropriate approach fits the characteristics of science so that it is very important for the teachers to apply this approach.

The integrated STEM approach can integrate the four elements of science to study a topic. The aspect of Science in the integrated STEM approach is defined by Hannover (2011) as a skill to use knowledge and scientific processes in analyzing natural phenomena and manipulating these phenomena so that they can be applied. The technical aspects are skills in explaining new technologies that can be developed and as a skill in using technology used to facilitate human work. Engineering aspects is a method used to design and produce a product. Mathematics aspects are skills to solve problems by interpreting solutions based on calculations and mathematical data. The science teacher, before applying this approach, must master the basic concepts of the four elements based on the basic competencies that the students must achieve. Zerihun et al. (2012); Fauth, et al. (2018); & Ma & Zhao (2018) stated students at different levels of the school have different learning needs. Knowing students' learning needs will be the basis for choosing integrated STEM approach as the right approach (Zerihun et al., 2012; Fauth et al., 2018; Ma & Zhao, 2018).

To analyze the characteristics of integrated science concepts, the integrated STEM approach is required. It is important to analyze the indicators of teachers who know this approach in the curriculum package starting from the preparation, implementation, and evaluation of learning. Teaching preparation compiles learning tools in the form of lesson plans, teaching materials, and student worksheets. Indicators of learning tools that use the integrated STEM approach are found in the selection of learning strategies, complemented by stages that fit the flow of this approach. Teaching material that integrates this approach includes a description of the four elements supplemented by explanations and examples. Student activities on the worksheet lead to applications of science that integrate technology, engineering, and mathematics. If the integrated STEM approach is found in the three learning tools, then the learning is by following with this approach (Auerbach & Andrews, 2018; Scaradozzi et al., 2019; Margot, & Kettler, 2019). The implementation of the application of the integrated STEM approach is clearly stated in the planning of learning. Learning tools developed with this approach will be applied in the learning process. Student-centered teaching activities and the stages of learning must be following the integrated STEM approach. Scaradozzi et al. (2019) states that the application of the approach is not

only on the planning of learning but the realization must be ensured as stated in the curriculum.

Ryu et al. (2019) found that STEM knowledge will open broad insights about the form of integration between science as knowledge and technological elements. In-depth knowledge of this approach provides an opportunity to produce competitive students. The teacher's STEM attitude is positive so that the encouragement and commitment could be raised to be applied in learning. Kelley, & Knowles (2016) & Shernoff et al. (2017) stated that the application of STEM does not only have an impact on the mastery of science concepts but students are trained to design a product as the learning outcomes. Radloff, & Guzey (2016) state that the initial STEM knowledge is necessary to be implemented so that the students can produce various products. integrated STEM approach is one of the approaches that must be applied because there is a policy to develop science and technology strongly and independently (Ritz & Fan, 2015). It is important to conduct a teacher readiness survey in implementing integrated STEM approach as a science learning approach.

When the related literature is examined, different results were encountered. The last previous studies on STEM at school level have found that teachers found the problem in the implementation of integrated STEM (Shernoff et al., 2017; Dare et al., 2018, Tao, 2019). Shernoff et al. (2017) found that the teachers were not believe that they can well prepare integrated STEM approach in the classroom. So, it needs to investigate the STEM attitude of teacher to help teacher in believing that they can doing well integrated STEM in the classroom, then look for the solutions to improve this STEM attitude. Beside that, Dare et al. (2019) found that teachers must struggle to balance the three disciplines of integrated STEM and they suggested that teachers must understand the integrated STEM education to implement the integrated STEM education. So, it needs to investigate the STEM knowledge of teacher to help teacher to easier to balance the three disciplines of integrated STEM in implementing integrated STEM in the classroom, then look for the solutions to improve this STEM knowledge. Additionally, Tao (2019) found that the teachers not familiar with STEM. So, it needs to investigate the STEM knowledge, attitude and application of teachers to help teachers to know the integrated STEM and then look for the solutions to help teacher how to implement the integrated STEM approach in the classroom. Any previous study by Wahono and Chang (2019b) researched to investigate the STEM attitude, knowledge and application of Indonesian teachers. What is not clear in this previous study is which provinces of science teachers come from and the STEM attitude, STEM knowledge and STEM application which investigated in this previous study were teachers' view not really STEM attitude, STEM knowledge and STEM application of teachers. This previous research only mentioned that the

sample of science teachers were come from rural, suburban, and urban school areas and not use test or observation to investigate STEM attitude, STEM knowledge and STEM application. So, we need conduct the research about Indonesian science teachers' views on STEM attitude, STEM knowledge and STEM application with sample from provinces of Indonesia with the largest number of teachers because Indonesia has many provinces. Indonesia consist of 34 provinces and if we look the number of Indonesian teachers in each province, we can divided Indonesia to three level, such as 11 provinces with the largest number of teacher, 12 provinces with middle number of teacher and 11 provinces with the lowest number of teacher (http://statistik.data.kemdikbud.go.id/index.php/page/smp). The four provinces of 11 provinces with the largest number of teacher such as Lampung, Banten, Jawa Tengah, and Jawa Timur can become sample which representative to Indonesia.

**Problem of Study**

The purpose of this study is to assess the Indonesian science teachers' views on STEM attitude, STEM knowledge, and STEM application. The science teachers' views on STEM attitude will help science teachers to believe that they can well implemented the integared STEM approach in the classroom. The science teachers' views on STEM knowledge can help science teachers to implement integrated STEM approach in the classroom. The science teachers' views on STEM application can be a reflection of science teachers in implementing the integrated STEM approach in the clasroom.

- What is the level of Indonesian science teachers' views on STEM attitude, STEM knowledge, and STEM application?

## Method

**Research Model**

Survey method was used in this research. The survey model is a descriptive research method. The opinions of the participants on a topic or interest, skill, ability, attitude, etc. It is the research that is done on larger samples than other researches. The purpose of the survey model is to define the nature and characteristics of objects, societies, institutions, events (Wallen and Faenkel, 2013). In this study, it is aimed to describe the characteristics of science teachers in Indonesia regarding STEM knowledge, attitude and practices.

**Participants**

The instruments are distributed using google form to 93 Indonesian science teachers from four of 11 provinces with the largest number of teacher in Indonesia such as Lampung, Banten, Jawa Tengah, and Jawa Timur. The science teachers in each province consist of 38 Indonesian science teachers from Jawa Tengah province, 18 Indonesian science teachers from Jawa Timur Province, 20

Indonesian science teachers from Banten province, and 17 Indonesian science teachers from Lampung Province. Those teachers are come from four of 11 provinces with the largest number of teacher in Indonesia (http://statistik.data.kemdikbud.go.id/index.php/page/smp).

**Data Collection Tools**

The data were collected by using questionnaire which adopted from Wahono and Chang (2019a). The instrument of this research was a questionnaire consisted of 30 questions which adopted from Wahono and Chang (2019a). The instrument was divided into three domains; STEM attitude, STEM Knowledge, and STEM application. The questions about STEM attitude were questions 1st to 3rd questions, STEM knowledge questions were the 4th to 7th questions, and the STEM application questions were 8th to 30th questions. Wahono and Chang (2019a) developed this instrument with Cronbach's alpha above 0.6. These values mean that the scale reliability of Cronbach's alpha considered acceptable. Therefore, this instrument was to be acceptable of internal consistency among domain.

**Data Analysis**

To analysis the data, authors used microsoft excel and used used frequency and percentage. Authors used likert-scale with ideal value; 5 for strongly agree, 4 for agree, 3 for neither agree nor disagree, 2 for disagree, and 1 for strongly disagree (Wahono and Chang, 2019b). The data consist of STEM attitude (STEM-At), STEM knowledge (STEM-K), and STEM application (STEM-Ap).

## Results and Discussion

**Indonesian Science Teachers' Views on STEM Attitude**

The results of STEM attitude survey of the Indonesian science teachers' views are presented on Table 1.

**Table 1.**

*Indonesian Science Teachers' Responses of STEM Attitude Items*

| Type | Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| 1st Question | 68.80% | 31.20% | 0 | 0 | 0 |
| 2nd Question | 63.40% | 36.60% | 0 | 0 | 0 |
| 3rd Question | 72.00% | 25.80% | 2.2% | 0 | 0 |
| Average of response of STEM-At (AR-STEM-At) | 68.07% | 31.93% | 0.73% | 0 | 0 |
| Ideal value of STEM-At (IVS) | 5 | 4 | 3 | 2 | 1 |
| Value of STEM-At (AR-STEM-At x IVS) | 3.4 | 1.25 | 0.02 | 0 | 0 |
| Average of Value of STEM-At | | | 4.67 | | |

Table 1 shows that the average of value of STEM-At is $\bar{X}$= 4.67. Table 1 shows that 68.07% of Indonesian science teachers have value above the average on STEM attitude and 31.93% of Indonesian science teachers have value below the average on STEM attitude. It means that most of Indonesian science teachers believe that Integrated STEM approach is important for teaching science in schools.

**Indonesian Science Teachers' Views on STEM Knowledge**

The results of STEM knowledge survey of the Indonesian science teachers' views are presented on Table 2.

**Table 2.**

*Indonesian Science Teachers' Responses of STEM Knowledge Items*

| Type | Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| 4th Question | 24.70% | 47.30% | 22.60% | 4.30% | 1.10% |
| 5th Question | 11.80% | 37.60% | 33.30% | 17.20% | 0 |
| 6th Question | 7.50% | 35.50% | 36.60% | 16.10% | 4.30% |
| 7th Question | 35.50% | 58.10% | 5.40% | 1.10% | 0 |
| Average of response of STEM-K (AR-STEM-K) | 19.88% | 44.62% | 24.48% | 9.67% | 1.35% |
| Ideal value of STEM-K (IVS) | 5 | 4 | 3 | 2 | 1 |
| Value of STEM-K (AR-STEM-K x IVS) | 0.99 | 1.78 | 0.73 | 0.19 | 0.01 |
| Average of Value of STEM-K | | | 3.72 | | |

Respondents' choices which must be answered by Indonesian science teachers in the aspect of STEM knowledge were varied because there were five choices of answers. The STEM knowledge is important to ensure conceptually that the research subjects have mastered the stages of learning with this integrated STEM approach. Data on Table 2 shows that 64.50% Indonesian science teachers have value above the average on STEM knowledge and 34.50% Indonesian science teachers have value below the average on STEM knowledge. It means that there were still Indonesian science teachers who believe that they do not have enough knowledge on integrated STEM approach.

**Indonesian Science Teachers' Views on STEM Application**

The results of STEM application survey of the Indonesian science teachers are presented on Table 3.

**Table 3.**

*Indonesian Science Teachers' Responses of STEM Application Items*

| Type | Strongly Agree (%) | Agree (%) | Neither Agree nor Disagree (%) | Disagree (%) | Strongly Disagree (%) |
|---|---|---|---|---|---|
| 8th Question | 20.4 | 55.9 | 19.4 | 4.3 | 0 |
| 9th Question | 23.7 | 58.1 | 12.9 | 5.4 | 0 |
| 10th Question | 32.3 | 45.2 | 16.1 | 6.5 | 0 |
| 11th Question | 12, 9 | 63.4 | 16.1 | 3.2 | 0 |
| 12th Question | 28 | 51.6 | 17.2 | 17.2 | 0 |
| 13th Question | 16.1 | 53.8 | 23.7 | 6.5 | 0 |
| 14th Question | 19.4 | 66.7 | 11.8 | 2.2 | 0 |
| 15th Question | 18.3 | 74.2 | 6.5 | 1.1 | 0 |
| 16th Question | 18.3 | 62.4 | 16.1 | 3.2 | 0 |
| 17th Question | 16.1 | 69.9 | 12.9 | 1.1 | 0 |
| 18th Question | 16.1 | 62.4 | 18.3 | 3.2 | 0 |
| 19th Question | 23.7 | 55.9 | 19.4 | 1.1 | 0 |
| 20th Question | 25.8 | 55.9 | 16.1 | 2.2 | 0 |
| 21st Question | 31.2 | 55 , 9 | 9.7 | 3.2 | 0 |
| 22nd Question | 33.3 | 57 | 7.5 | 1.1 | 1.1 |
| 23rd Question | 32.3 | 45.2 | 15.1 | 7.5 | 0 |
| 24th Question | 30.1 | 49.5 | 16.1 | 3.2 | 1.1 |
| 25th Question | 37.6 | 39.8 | 9.7 | 12.9 | 0 |
| 26th Question | 20.4 | 63.4 | 15.1 | 1.1 | 0 |
| 27th Question | 15.1 | 55.9 | 22.6 | 6.5 | 0 |
| 28th Question | 21.5 | 59.1 | 19.4 | 0 | 0 |
| 29th Question | 19.4 | 63.4 | 15.1 | 1.1 | 1.1 |
| 30th Question | 16.1 | 60.2 | 20.4 | 3.2 | 0 |
| Average | 23 | 57.6 | 15.5 | 3.8 | 0.1 |

Data on Table 3 shows that 80.56% Indonesian science teachers have value above the average on STEM application and 19.44% Indonesian science teachers

have value below the average on STEM application. This means that not all Indonesian science teachers believe that they worthy implement the integrated STEM approach.

Indonesian science teachers' views are very good on STEM attitude with an average value of 4.68, a moderate-level category on STEM application with an average value of 3.99, and a low-level category on STEM knowledge with an average value of 3.72. It can be caused by the science curriculum in Indonesia has learning outcomes with two attitude competence from four competence such as spiritual attitude competence, social attitude competence, knowledge competence, and skills competence (Ministry of Education and Culture, 2016). So, Indonesian science teachers' views on STEM attitude become the highest level to other STEM domains. This result in line with Wahono and Chang (2019b) found that science teachers have very good attitude, moderate-level category in the application, and low-level category in knowledge regarding STEM education. However, values of all STEM domains in this previous study are lower than the result of this current study. Wahono and Chang (2019b) found the average of value of STEM attitude is $\bar{X}$ = 3.94, STEM application is $\bar{X}$= 3.03, and STEM knowledge is $\bar{X}$= 2.5. It can be caused by good atmosfer of STEM Education workshop or seminar in Indonesian since year 2019 has given positive effect to STEM attitude, STEM application and STEM knowledge of Indonesian science teachers.

Most of Indonesian science teachers have value above the average on STEM attitude. It's mean most of Indonesian science teachers believe that Integrated STEM approach is important for teaching science in schools. It's because they already know STEM. The Indonesian science teachers' anxiety was revealed because of the demand to teach science in an integrated manner while the educational background of the teachers was just homeroom teachers. Those who have educational backgrounds in biology, physics, and chemistry must teach science in an integrated manner which requires learning approaches that are oriented towards integrating knowledge (Ministry of Education and Culture, 2016). The STEM approach becomes one of the choices for Indonesian science teachers to overcome anxiety. Based on the survey, most of Indonesian science teachers believe that it is very important to use integrated STEM approach in teaching science and they were interested in integrated STEM approach. So most of Indonesian science teachers have value above the average on STEM attitude. Nordlöf et al. (2019) stated that the interest in learning strategies is determined by the perceptions resulted from the exploration of a teacher's self-awareness. The results of this study emphasize that awareness of the limitations is needed so that it creates an interest that leads to a commitment to implement a new way of teaching (Lederman, & Lederman, 2016). However, about 31.93% of Indonesian science teachers have value below the average on STEM attitude. It needs improvement to

persuive Indonesian science teachers to believe that integrated STEM approach is important for teaching science in schools.

Most of Indonesian science teachers have value above the average on STEM knowledge. However, some Indonesian science teachers who felt that they did not have enough knowledge integrated STEM approach. The survey found more than 50% of Indonesian science teacher believe that they have limited knowledge in integrating science, technology, engineering, and mathematics, and not enough knowledge about weaknesses and advantages of integrated STEM approach and also still need knowledge to decide the integrated STEM as teaching method or not a teaching method. The Indonesian science teachers have a better understanding when they believe that they can integrate the four elements of STEM. Indonesian science teachers with deep knowledge of STEM can facilitate students in solving science problems (Kim & Keyhani, 2019). The survey results conclude that even though most of Indonesian science teachers stated that they already know the term of STEM, it is not enough but it needs practice to apply it in learning.

Even though most of Indonesian science teachers have value above the average on STEM application, but there is about 19.44% of Indonesian science teachers have value below the average on STEM application. Indonesian science teachers already know and implement integrated STEM because good atmosfer of STEM Education workshop or conference in Indonesian since year 2019 has given positive effect to Indonesian science teachers to learn and practice integrated STEM. So, they have value above the average on STEM application. But, 19.44% of Indonesian science teachers have value below the average on STEM application. It can be caused by the curriculum in Indonesia promoted scientific approach as main approach in the learning not integrated STEM approach, so Indonesian science teachers didn't implement the integrated STEM approach in the clasroom. It's need efforts to promote integrated STEM approach to science teacher through workshop or conference to Indonesian science teachers all over Indonesia areas and also need to include in national science curriculum as one of the main teaching approach. Because integrated STEM approach is needed to practice in the classroom not only as a knowledge in our mind.

This research has obtained the level of Indonesian science teachers' views on STEM attitude, STEM knowledge, and STEM application. Indonesian science teachers believe that they have very good STEM attitude, moderate-level category on STEM application, and low-level category on STEM knowledge and most of Indonesian science teachers believe that Integrated STEM approach is important for teaching science in schools, believe that they have enough knowledge on integrated STEM approach, and believe that they worthy implement the integrated STEM approach.

## Recommendations

For further study it can be used participant from 34 provinces in Indonesia, and qualitative research techniques, observation, and instrument test can be used to explore and investigate the STEM attitude, STEM knowledge, and STEM application. STEM Education must be integrated 3 dimension; STEM attitude, STEM knowledge and STEM application. This findings recommended to science teachers or science educators in Indonesia to promote STEM Education in the national curriculum especially in science subject to improve STEM attitude, STEM knowledge, and STEM application.

## Acknowledgements

The authors gratefully acknowledge to all Indonesian science teachers who become respondents in this research. All authors have equal contributions

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