An Investigation of Indonesian In-Service Mathematics Teachers’ Perception and Attitude Toward STEAM Education

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Abstract. To face the global challenge, people need to master mathematics comprehensively which one of the ways is to integrate it with other fields such as science, technology, engineering and arts. Therefore, the implementation of STEAM Education approach is considered to be essential for in-service mathematics teachers especially in Indonesia. This study aimed to investigate the perceptions and attitudes of Indonesian in-service mathematics teachers towards the application of STEAM-based education in the teaching mathematics. Cross-sectional survey was used in this study engaging 110 respondents along the survey. The result was that STEAM Education is nor well-known by the majority of the respondents. For the perception, those who knew STEAM Education mostly believed that each topic of this approach was connected to each other, otherwise for those who did not know STEAM Education mostly said that each topic was stand alone. As for the attitude of respondents also divided into two, the first group of respondents stated that STEAM Education will be increasingly popular in the future and they will feel happy if teaching mathematics with STEAM Education. Whereas the second group of respondents looked more pessimistically related to projections of future application of STEAM Education that would be less popular, not to mention that they would feel unexcited to teach mathematics with the STEAM Education approach.

Keywords: STEAM Education, cross-sectional survey, perception and attitude

1. Introduction

21st-century education is education oriented to easy access to information, ease of use of computing machines, the ability to reach all routine work (autonomous), and has a high level of accessibility from anywhere and at any time [1]. This is a response to the rapid flow of information and current technological developments where every human being must be integrated with digital technology both in terms of physical and mental. In facing these challenges, a nation must be able to prepare its future, especially through the education sector. The education that is held is certainly an
education that supports the achievement to the mastery of 21st-century skills, one of which is critical and creative thinking skills [2], which is integrated with current technological developments.

Indonesia has responded to these conditions by incorporating STEAM (Science, Technology, Engineering, Art, and Mathematics) Education into the 2013 curriculum revision. By definition, STEAM Education is an educational process in which learning integrates four aspects namely Science, Technology, Engineering, Arts and Mathematics which aims to equip students with critical and creative thinking skills which ultimately makes them more marketable in the world of work [3]. Many countries have promoted STEAM into their education systems with the aim of being able to equip their people with multidimensional capabilities to face global challenges, one of which is in South Korea [4] and many countries in Europe such as the report from Erasmus + Program of the European Union [5]. Therefore, it is not wrong if Indonesia also wants to equip its people with these multidimensional skills. Then, what about the STEAM learning conditions in Indonesia? In the aspect of learning, there are several educational institutions in Indonesia that have implemented STEAM learning as part of its curricula such as Sampoerna Academy (https://www.steamindonesia.id/) and Singapore Intercultural School (https://sisschools.org/about-sis ). But from the data found, there are still few Indonesian schools that purely adapt STEAM Education as part of their curriculum. Adaptation of STEAM learning is considered important to be done for the Indonesian people to improve the quality of Indonesian human resources in order to compete on the world stage, especially related to the ability and skills to produce science and technology-based products. Therefore, it is deemed necessary to do a massive introduction of STEAM Education.

There are many benefits and benefits obtained from the application of STEAM-based education in the teaching and learning process, such as one of them is in the context of the application of STEAM in mathematics learning can improve students' critical thinking skills [6], where critical thinking becomes a very important skill for now. Besides STEAM Education-based learning also has the potential to improve students' cognitive abilities and creativity [7]. In addition, many studies have examined the application of STEAM Education in learning process in terms of (1) curriculum as conducted by Madden in 2013 [8]; (2) media as Park did in 2012 [9], by Cools in 2018 [10], and by Meletiou in 2019 [11]; (3) as well as learning as Munawar did in 2019 [12]. Of the many studies, there is still few researches related to the attitudes and perceptions of mathematics in-service teachers related to STEAM Education-based learning. However, this is very important because their attitudes and perceptions determine how the acceptance and sustainability of STEAM Education in the classroom will be achieved.

Based on the description, the question that arises is how are Indonesian mathematics in-service teachers' perceptions and attitudes toward the implementation of STEAM-based education in the teaching-learning process? So, the purpose of this research is to investigate the perceptions and attitudes of teachers towards the application of STEAM-based education in the teaching and learning process of mathematics.

2. Method
   a. Background

   This research is a survey-based study with a cross-sectional study method of in-service mathematics teachers' beliefs and attitudes about STEAM Education. The subjects of this study were 110 junior high school in-service mathematics teachers from 4 districts namely Sragen Regency, Boyolali Regency, Sukoharjo Regency, and Klaten Regency in Central Java Province from January to December 2019. These regencies were chosen because in the same period, researchers were conducting STEAM Education training for the mathematics in-service teachers of the four regencies. The names of the respondents were anonymous so this research does not violate research ethics.

   b. Data Collection
Data were collected using a questionnaire method that was distributed randomly. In the questionnaire method, the question points that are designed are a modification of the question points that have been developed by Radloff and Guzey [13]. The modification had been done due to the research conducted by Radloff and Guzey barely has the same point of research with the current study which their research was on the STEM Education while the current study was on the STEAM Education. The other differences are the respondent to be asked for the questionnaire, the question of ethnicity that is not used in this research as the majority of the respondents were Javanese, and the STEAM visualization that is not used in this research.

The questionnaire was validated by 2 experts related to language and 2 experts from STEAM. Based on the results of the validation it is found that linguistically has a good level of readability and there are no ambiguous sentences. Whereas in content, the questions given are already valid in theory. Next, the question points in the questionnaire were transformed into a Google Form and tested on a limited basis to 7 mathematics teachers from several schools in Sukoharjo regency aged between 23 - 45 years. After the teachers filled out the questionnaire given, they were interviewed related to their impressions after completing the questionnaire and obtained the results of the interview in terms of language, the teachers did not experience difficulties either in reading or understanding the questions given. But in terms of construction, some teachers experienced some difficulties at the beginning, namely in the adjustment phase with the interface from the Google Form provided. Next after getting help from researchers, teachers who experience difficulties can adjust to the existing interface. So theoretically and empirically, the questionnaire developed was valid and practical to use. The use of Google Form in distributing questionnaires is due to considerations related to the ease of analyzing the results and the ease of disseminating them. The collected data then be analyzed quantitatively.

c. Instrument

The questionnaire developed consisted of four parts, in which the first part contained questions related to the demographics responded such as age, gender, and school location. Next in the second part is about the experience of teachers in teaching so far, such as how long they have been teaching mathematics, do they use teacher-centered approaches or active learning (using Semantic Differential Scale between 1 (teacher-centered) to 10 (active learning) [14]), and whether they wish to change the way they teach in the future. Furthermore, the third part is related to respondents' knowledge regarding STEAM Education as to whether they know what STEAM Education is. This question will give a split answer between "yes" and "no". Each of these answers will be followed by the following questions which can be seen in Table 1. The last part of the questionnaire is related to the attitude which consists of respondents' projections on the future application of STEAM Education and their feelings if they apply STEAM Education.

| Type of Questions | For the “YES” answer | For the “NO” answer |
|-------------------|----------------------|---------------------|
| Understanding     | Please define STEAM Education according to your knowledge. | Do you think that Science, Technology, Engineering, Arts, and Mathematics can be combined to generate a good quality of teaching-learning process? Why? |
| Perceive          | How related to one another do you perceive STEAM Education to be? (Using 1-10 scale) And explain why you say so. | How related to one another do you perceive STEAM Education to be? (Using 1-10 scale) |
| Projection        | Do you think that in the future there will be more teachers who implement STEAM Education in class? |
| Feeling           | Do you think that you will enjoy teaching mathematics in your class by using STEAM Education if you have to? |
3. Result and Discussion

Result

The questionnaire was distributed online and randomly to 122 in-service mathematics teachers and only 110 teachers responded to the questionnaire that was distributed while the other 12 in-service teachers did not respond the questionnaire. From the 110 teachers, the following results were obtained:

1) Respondents’ Demographic

From the total respondents who completed the questionnaire, demographic results were obtained that the majority of respondents were under 30 years old with a proportion of 60.9% followed by the number of respondents aged 31-50 years old and over 50 years old with each proportion being 36.3% and 2.7%. Of all the respondents who answered the questionnaire, almost 70% were women and the rest were men. As many as 80.9% of respondents work in urban areas while the rest are in rural areas. From the 110 respondents who answered the questionnaire, around half worked at the elementary school level, nearly 30% worked at the junior high school level, and the rest worked at the high school level. Details of the data can be seen in Table 2.

Table 2. Respondents’ demographic

| Type of Demographic | Specification | Quantity |
|---------------------|---------------|----------|
| Age range (in years old) | Below 30 | 67 |
| | 31-50 | 40 |
| | Over 50 | 3 |
| Gender | Male | 36 |
| | Female | 74 |
| School Location | City | 89 |
| | Countryside | 21 |
| Level of School | Elementary School | 57 |
| | Junior High School | 31 |
| | Senior High School | 22 |

2) Teaching Experiences

The second question is related to the respondent's experience of teaching. Related to how long they have taught as mathematics teachers, the majority have experience between 1-5 years of teaching that is as much as 42.7% and those who have experience over 10 years to be the least amount which is only about 11%. The rest are in the category of None and 6-10 years of teaching with percentages for each of these categories around 18% and 28%. From the number of respondents, the majority stated that there was a possibility for them to change the way they taught mathematics in the future by 61.8%, the rest stated not sure and no with 28.1% and 1% respectively. This detail can be observed in Table 3.

Table 3. Respondents’ experience in teaching mathematics and the possibility for them to change the way they teach

| Point of Question | Specification | Quantity | Total |
|-------------------|---------------|----------|-------|
| How long they have been a math teacher (in years) | None (less than 1 year is considered as none) | 20 |
| | 1 – 5 | 47 |
| | 6 – 10 | 31 |
Point of Question | Specification | Quantity | Total |
--- | --- | --- | --- |
A possibility to change the way of teaching in the future | Yes | 68 | \( \) |
| Not Sure | 31 | 110 | \( \) |
| No | 11 | \( \) | \( \) |

Related to the learning approach that they use in teaching so far, it is found that the majority of respondents choose the 4-7 scale, which means that the frequency they use using the approach of teacher-centered and active learning is relatively balanced. Only a few respondents in total used both teacher-centered and active learning approaches. Its details can be observed in the following figure:

![Figure 1. A teaching approach that has been used](image)

3) Respondents’ understanding of STEAM Education

The third question is related to their knowledge about STEAM Education, and based on the survey, 47% (52 in-service teachers) of the respondent said “yes” and the rest said “No”. For those who said “Yes”, there are two questions asked for them namely a) how they define STEAM Education and b) how each STEAM Education components are related to each other according to them. The respondents’ answer has been summarized into some codes that categorized into four themes which are instruction, discipline, and exclusion. Its details can be seen as follows:

| Theme | Code | Number of Respondents | Percentage |
| --- | --- | --- | --- |
| Instruction | Contextual | 13 | 25.00% |
| | Critical Thinking | 7 | 13.46% |
| | Teamwork | 6 | 11.54% |
| | PBL | 5 | 9.62% |
| | Creativity | 5 | 9.62% |
| | Other | 2 | 3.85% |
| Discipline | Connected | 4 | 7.69% |
| | Rank | 3 | 5.77% |
| | Integration | 3 | 5.77% |
| Exclusion | Less Prominent | 4 | 7.69% |
| Total | | 52 | 100% |

According to Table 4, there are five codes that categorized under an instructional theme which are contextual, critical thinking, teamwork, PBL, and creativity with 25%, 13.46%, 11.54%, 9.62%, and 9.62% respectively. In addition, three codes are categorized under discipline theme namely connected that is recorded from 4 respondents, rank that was noted from 3 people as many as integration. While only 4 of them stated that STEAM Education is less prominent to be implemented in the class. All in
all, the majority of the respondents defined STEAM Education as an approach that closes to the real world. This result is in line with the research conducted by Stohlmann, Moore, and Roehrig in 2012 which stated that STEAM Education is basically related to real-world context [15].

For the second question, 75% of the respondents chose scale “6” or greater which means that according to them, the component of STEAM Education was moderately connected to strongly connected to each other (it can be seen in Figure 2). While for the connectedness level of “5” to lower was chosen by only 25% of the respondent.

![Figure 2. Perceives of the connectedness of STEAM Education](image)

After the respondent asked for their opinion regarding the connectedness of each component of STEAM Education, then they were asked to explain their reasons. Their explanations are coded into and three themes emerge based on the codes namely Specialized, General, and Other. The Specialized consists of (a) Dependent and (b) Dependent and ranked. While the General consists of (a) Related, (b) Related but unique, and (c) Related but dependent. The details can be seen in the following table.

| Theme     | Coding                  | Frequency | Percentage |
|-----------|-------------------------|-----------|------------|
| Specialized | Dependent               | 8         | 15.38%     |
|           | Dependent and ranked    | 2         | 3.85%      |
| General   | Related                 | 32        | 61.54%     |
|           | Related but unique      | 3         | 5.77%      |
|           | Related but dependent   | 4         | 7.69%      |
| Other     | Vague                   | 1         | 1.92%      |
|           | None                    | 1         | 1.92%      |
|           | Hard                    | 1         | 1.92%      |
| **Total** |                         | **52**    | **100%**   |

The Dependent code was chosen because some of the respondents say that the elements of STEAM Education were dependent on each other such as one respondent who said: “all elements support one another”. Another respondent also said, “In STEAM Education, to do one part, students have to use knowledge from other parts”. Dependent and Ranked coding was chosen based on respondents’ answers who ranked the component of STEAM Education. The Related code simply taken from respondents’ answer who put word “related” into their response such as one respondent wrote, “Every element of the STEAM Education are related to each other”, and another said that “Art can be in every aspect such as mathematics, engineer, technology and science. So, they are all related to each other”. The Related but Unique was used when the respondent tries to distinguish the relationship of each component toward their abilities such as one respondent who said: “They can be interrelated, but they can also stand on their own”. Related but Dependent code was used when the
respondents relate each component and believe that the components are overlapping. There are also some respondents who answered differently from previous codes such as unclear answers given Vague code, respondents who did not answer those who were given code None, and respondents who answered that STEAM Education was difficult who were given a Hard code.

For those who answer “No” (58 respondents), there were also two questions that have been asked to them such as (a) Are Science, Technology, Engineering, Arts, and Mathematics can be combined to generate a good quality of teaching-learning process? Why? and (b) How related to one another do they perceive STEAM Education to be? For the first question, the majority of the respondents stated that the five subjects to generate a high-quality teaching process, while the rest said maybe and no.

![Figure 3. Respondents’ answers regarding the possibility to combine the five topics](image)

Next, regarding to their reason why they chose their answers, there are some codes used to classify the answers. The code used for respondents who said "Yes" is Related, Dependent, and Related and Dependent. For respondents who answered "Maybe" then the code used was Related but difficult. Next, for those who answer "No", the code used is Independent and Difficult. All those codes were chosen based on the respondents’ answers. Overall, most respondents answered “Yes” because they found that all aspects of STEAM Education were related to each other. While for those who answer “Maybe” because they think that the subjects are related to each other but they believe it is difficult to integrate them into each other. While for the respondents who chose “No” because they think those components stood alone and it is hard to combine each other. The details can be observed in the following table:

**Table 6. Respondents’ answer toward the reason of why the components can be combined**

| Answer      | Code              | Frequency | Percentage |
|-------------|-------------------|-----------|------------|
| Yes         | Related           | 24        | 41.38%     |
|             | Dependent         | 12        | 20.69%     |
|             | Related and Dependent | 11   | 18.97%     |
| Maybe       | Related but difficult | 8     | 13.79%     |
| No          | Independent       | 1         | 1.72%      |
|             | Difficult         | 2         | 3.45%      |
| **Total**   | **58**            |           | **100%**   |

For the second question regarding how to relate those components to each other, most of the respondents rated “6” or greater with 84.48%, while the rest chose “5” or bellow. For details can be seen as follows:
4) Respondents’ Attitude of STEAM Education

In this part, both groups of respondents, group of respondents who know STEAM Education and group of respondents that do not know STEAM Education, are asked the same question regarding their projection and their attitude toward STEAM Education. The first question asks about their projection toward the future STEAM Education will be more common for mathematics teachers to be implemented in the class, and the second question asks about their feeling when they have to teach mathematics by using STEAM Education. The respondents’ answer for both questions can be seen in the following figures:

According to Figure 5., most of the in-service teachers in the first group (just below 80%) believe that in the future there will be more mathematics teachers that will use STEAM Education in their classes. In contrast, the second group shows more pessimistic that they projected in the future the use
of STEAM Education will not be as favourable as today. Meanwhile, in Figure 6., most of the respondents in the first group will feel happy when they have to teach mathematics using STEAM Education with about 60% of them. While for the second group of respondents, approximately 50% will feel not excited to teach mathematics by using STEAM Education.

Discussion

The arrangement of this discussion is the same as in the section of result. The first thing that will be discussed is in demographic terms from the respondent. Respondents who answered that they knew that STEAM Education, out of 52 people, came from respondents under 30 years old at 42 people, while the rest were aged 31-50 years. Of the 52 people, 61% were male while the rest were female. As for their institutional background, 72% come from mathematics teachers who teach in primary schools, 20% in junior high schools, the rest come from high school teachers and they all teach in schools located in cities. This shows that STEAM Education is more familiar to young teachers, which is under 30 years, which is made possible by many things, one of which is that they are the youngest graduates of this age group and get the latest information related to learning approaches, one of which is STEAM Education, which was first coined 2011[16]. In addition, STEAM Education is better known by mathematics teachers who teach in schools located in urban areas, the majority of which are elementary school level. This is possible because in urban areas access to information is more easily accessible, and many STEAM Education trainings are aimed at mathematics teachers at the elementary school level because the junior and senior high levels have gone through abstraction thinking[17], so it is natural that many STEAM Education trainings for teachers Elementary school.

Next is about the perception from the respondents toward STEAM Education, most of the respondents perceive STEAM Education as contextual approach followed by critical thinking, teamwork, problem-based learning, and creativity approach as can be seen in Table 4. This perception is in line with the condition of STEAM Education that it is a real-world based approach which need critical thinking, creativity and teamwork to connect each of the components to solve the problem [7][16]. Most of those people who know STEAM Education (group 1) said that each topic is connected to each other and overlapping which means to learn one topic, they believe that students need to learn other topics as well (see Table 5). Otherwise, the majority of those who did not know STEAM Education (group 2) believe that each topic was stood alone and cannot be integrated to each other (see Table 6). Interestingly, this difference also continues to their attitude in terms of projections related to STEAM Education in the future and their opinion is related if they are required to apply STEAM Education in their classrooms. Group 1 feels that in the future STEAM Education will be increasingly recognized by mathematics teachers, while Group 2 believes otherwise (see Figure 5). While related to what feelings they will feel when they teach STEAM Education in class, Group 1
states that they will be happy if they teach mathematics by using STEAM Education in class, while Group 2 will feel less excited when teaching mathematics with STEAM Education (see Figure 6).

4. Conclusion

In summary, research related to the perception and attitude of in-service mathematics teachers toward STEAM Education gets many findings and views. In general, STEAM Education is still not widely known based on the results of a survey of respondents. Their perception regarding STEAM Education is also divided into two, for those who know STEAM Education states that each topic in STEAM Education is interrelated and more contextual in nature. Whereas those who do not know STEAM Education see the STEAM Education component glimpse independent of each other without interrelation. As for the attitude of respondents also divided into two, the first group of respondents stated that STEAM Education will be increasingly popular in the future and they will feel happy if teaching mathematics with STEAM Education. Whereas the second group of respondents looked more pessimistically related to projections of future application of STEAM Education that would be less popular, not to mention that they would feel unexcited to teach mathematics with the STEAM Education approach.

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