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Exploring the relationship of teachers' attitudes, perceptions, and knowledge towards integrated STEM

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Abstract. The purpose of this study was to investigate the relationship of teachers' attitudes, perceptions, and knowledge towards integrated STEM. The participants in this study were 185 Indonesian teachers from the eastern, western, and central regions of Indonesia with the difference in ethnic and culture. The exploration of these three domains was based on the demographic data, teachers' attributes, and their contribution to the educational system. An adopted and adapted STEM questionnaire was administered online which comprises the Likert-scale items that were used as a research tool. The results showed that the teachers have a positive correlation between the attitude and knowledge towards integrated STEM, especially for the quality of education in Indonesia. The implication of this research was about the possibility to elaborate further on the domain of components or sub-components that is related to the current problems faced by teachers towards integrated STEM.

Keywords: Integrated STEM, attitudes, perceptions, knowledge, Indonesia

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INTRODUCTION

STEM has been defined as the connection between disciplines of integrating technology and engineering practices into current mathematics and science lessons (Bybee, 2013). STEM also refers to problem solving and gives the emphasis on drawing the concepts and procedures from mathematics and science to be connected with the engineering design and technology tool (Shaughnessy, 2013). Moreover, STEM is one method in teaching approach that can provide promising studies by providing evidence which focuses on facilitating students to understand the world as a whole rather than in parts. STEM also removes the barriers of current teaching practices by giving the experience for students' talent development (Kennedy & Odell, 2014; Aslam et al., 2018; Baharin et al., 2018; Margot & Kettler, 2019). Hence, in implementing integrated STEM teaching in the school context, teachers are also in charge to give the inspiration for students (Van Driel et al., 2005). In other hands, teachers are also struggling to understand the in-depth definition of STEM education whereas teachers' views of integrated STEM can affect their teaching in daily practice (Dare et al., 2019). For instance, teachers' practical knowledge can be indicated their experiences of what is learned, taught, and started to be taught by teachers including their actions into teaching practice (Van Driel et al., 2001).

There are several factors that could become the barriers faced by the teachers to integrated STEM education, such as their conceptual framework, teachers' professional development and teachers' attributes that consists of their attitudes, perceptions, and knowledge towards STEM (Wang et al., 2011; Breiner et al., 2012; Al Salami et al., 2015; Park et al., 2016; Radloff & Guzey, 2016; Kelley & Knowles, 2016; Thibaut et al., 2017; Srikoom et al., 2017; Holmlund et al., 2018; Margot & Kettler, 2019; Aldahmash et al., 2019; Bartels et al., 2019). Teachers are also facing the difficulties in creating appropriate links through STEM domain, resulting in students become uninterested in science and mathematics. Students' low motivation also could happen when they are taught about the connection to cross-cutting ideas and the real-world situations (Kelley & Knowles, 2016). Moreover, Dare et al (2019) found that teachers' competencies can be identified as learning thoughts and their understanding toward integrated STEM. Thus, it is essential to investigate what teachers think about STEM as well as its impact on learning.

Asking the teachers to define what STEM education other than their discipline could create new challenges and knowledge gaps (Stinson et al., 2009). By its definition, STEM can combine at least two areas from STEM by enhancing teachers' learning concepts (Kelley & Knowles, 2016). Consequently, it is important to see teachers' competencies that can be learned and implemented by the teachers depending on their learning, thinking, and understanding toward integrated STEM (Dare et al., 2019). From previous research has been shown that teachers' attitudes were different in reacting to the idea of integrated STEM (Denessen et al., 2015; Al Salami et al., 2015; Thibaut et al., 2017; Aldahmash et al., 2019). Furthermore, teachers' perceptions could also impact their beliefs toward learning and teaching (Nathan & Koedinger, 2000; Wang et al., 2011; Park et al., 2016; Srikoom et al., 2017; Margot & Kettler, 2019). However, the most important factor is also about the teachers' knowledge in which some researchers argue that the teachers' knowledge can influence how the teachers gaining the student's motivation and their achievement in learning (Wang et al, 2013; Stohlmann, 2019; Shin et al., 2018; Stohlmann, 2019).

Since these have become a general debate of most researchers, teacher attitudes, teacher perceptions, and teacher knowledge of STEM can be intertwined and could identify their understanding of integrated STEM. The understanding is also important and is a focus of some previous research. This research has a concern on teachers' attitudes, perceptions, knowledge, and sub-components namely, cognitive, affective, self-efficacy, concern, interest, content, and pedagogy of integrated STEM. Moreover, an analysis could be done to analyze how these factors are connected each other. However, based on the suggestion by Vossen et al (2019), teachers are initially educated to teach issues in single disciplines only without training them to study the integrated STEM. Previous studies have indicated the empirical evidence about the effectiveness of the design process in facilitating the integration of STEM concepts (Roehrig et al., 2012; Estapa & Tank 2017). Estapa & Tank (2017) found that engineering design is a context that can help students to identify STEM content and connect it to their daily activities. Roehrig et al (2012) found that many teachers were only familiar with science and mathematics contexts, but they missed the teaching the content to connect it with the technology as a tool and engineering as a design. Talking further, Radloff & Guzey (2016) argued that integrated STEM can influence learning approach activities and giving students' the positive views towards their careers, skills, and conceptions. These findings also have been rising the discussion about whether or not integrated STEM should be the focus of scientific and engineering learning process.

Previous studies have found that attitudes, perceptions, and knowledge of teachers have a connection with each other. For instance, Evans & Durant (1995) reported the interrelationship of the structure of attitudes and the concept of knowledge towards science and indicating a positive correlation of scientific understanding and general/ specific attitudes. In a similar vein, Wahono & Chang (2018) argued that there is a positive relationship between attitudes and knowledge of teachers which is indicated by a level of the medium interrelationship. Bell (2015) found the interrelationship between teachers' perceptions and their personal knowledge to link with the effectiveness of understanding STEM education. Wang et al (2011) reported the relationship between teachers' perceptions and teachers' knowledge in their integration of STEM in the classroom practice and found that this connection can help the teachers to design teaching processes and enhance students learning. However, Lieflander, et al (2016) found that there was a weak relationship between teachers' knowledge and attitudes indicated by the scientific understanding of teaching implementation. In short, some research has reported that there is a relationship between attitudes, perceptions, and knowledge of teachers to complete each other. These findings suggested that the relationship of attitudes towards knowledge should be engaged in learning to become less exploitative. However, the relationship between STEM attitudes and knowledge are more obvious than other factors. This relationship were expected to enhance the implementation of STEM education in all disciplines by focusing on teachers' attitudes and knowledge of STEM.

To access the limited research and discussion toward the coincident relationship between attitudes, perceptions, and knowledge of teachers toward teaching and learning STEM, it will be better to begin with the understanding on how teachers' thinking related to STEM education and then look deeper into teachers' attributes. Therefore, this study will explore teachers' attitudes, perceptions, and knowledge towards integrated STEM. To do this, the results from this study may uncover possible problems experienced by teachers when teaching in the classroom and can show the differences between teachers' thinking and understanding of integrated STEM. Concretely, the research questions of this study are as follows.

1. What are the relationship of teachers' attitudes, perceptions, and knowledge towards integrated STEM?
2. What are the differences between teachers' attributes if compared to the demographic data, namely gender, teaching experience, area specialization, and the subject of teachers?

THEORETICAL BACKGROUND

As described above, in this study, we divided the components of attitudes, perceptions, and knowledge into sub-components such as cognitive, affective, self-efficacy, concern, interest, content, and pedagogy of integrated STEM. Regularly, effective teaching is the impact of a positive accessible integrated curriculum rather than less effective teaching. There is a possibility that highly-competent teachers might also have good personal behavior through self-efficacy, cognitive, affective skills, and confidence in their teaching abilities (Guskey, 1998). Some researchers argue that attitudes can be divided into cognitive and affective which focuses on identifying, presenting weaknesses, and maintaining the existing situation (Avidov-Ungar & Eshet-Alkalai, 2011). Schau et al (1995) found the structure of attitudes into a dimension of affective which is related to positive feelings such as a cognitive as a capacity and thinking skills of teachers and value as usefulness, relevance, and statistical perception in their daily life. Furthermore, they reported that the components of attitudes consist of three dimensions i.e. value, affective component, and cognitive component. However, as we know that in the psychological aspects, attitudes consist of good/bad or pleasant/unpleasant.

The term of attitude is defined as the evaluation of the whole object on several dimensions (Maio& Haddock, 2014). Teachers' positive or negative attitudes will be affected by student attitudes whereas assessing teachers' attitudes can be seen by students' attitudes in learning activities (Frenzel et al., 2009). Van Aalderen-Smeets et al (2012) argued that attitude is one of the personality aspects that can be influenced by the individual's feelings such as cognitive, values, motivation, and self-efficacy. Likewise, understanding teachers' perceptions in a core concept can influence students' understanding of the learning (Yasar et al., 2006). Teachers' perceptions can be influenced by teachers' beliefs toward learning and teaching (Nathan & Koedinger, 2000). Park et al (2016) explained that teachers' interests can be seen by their learning view through their convergent thinking, creativity, and their characters. Hence, Margot & Kettler (2019) divided teachers' concerns into six categories of pedagogical challenges, curriculum challenges, structural challenges, concerns about students and assessments, and lack of teacher support. In this case, the attention and aspects of teacher interest can be influenced by enhancing students' motivation career and achievement in the learning process (Shin et al., 2018; Stohlmann, 2019).

For this reason, teachers' perceptions can affect how they design their teachings based on a process of STEM integration unit and students' learning outcomes (Wang et al., 2011). It can affect students' learning and shaping students' decisions about their future careers and interests in understanding of STEM (Breiner et al., 2012). Consequently, the teachers need to explain why a particular proposition happens, why it is worth to know, and how it relates to other disciplines. As a teacher, there is a need to gain knowledge that enables them to make a relation to their subjects or specific subjects effectively. It is called a combination of content and pedagogy of knowledge (Shulman, 1986). Stohlmann et al (2012) explained that knowledge has the relation to the content and pedagogy. The lack of teachers' content knowledge can affect their confidence in implementing and guiding the students' works.

Teachers should not only capable of defining the truth in domain concepts but also should able to explain content and pedagogy. For example, Kelly & Knowles (2016) found that the difficulties of teachers to implement and make a link of teaching could affect the student's disinterest in learning. Another example, Avidov-Ungar & Eshet-Alkalai (2011) argued that knowledge is a specific domain of facts and proofs based on the subject taught by the teachers. General knowledge about teaching and learning process included the educational goals, values, and targets identical by the teacher with comprehensive pedagogic knowledge. This knowledge could help the teacher to understand how students construct their knowledge, obtain skills, and develop learning practices, Moreover, Wang et al (2013) found that teachers need more content knowledge and problem-solving process to integrated STEM disciplines yet sometimes they face difficulties to understand the nature of science. For that reason, in this research, the construction of teachers' attitudes, perceptions, and knowledge can be visualized as shown in figure 1 which concretely shows the conceptual framework of the mutual relationships between each dimension.

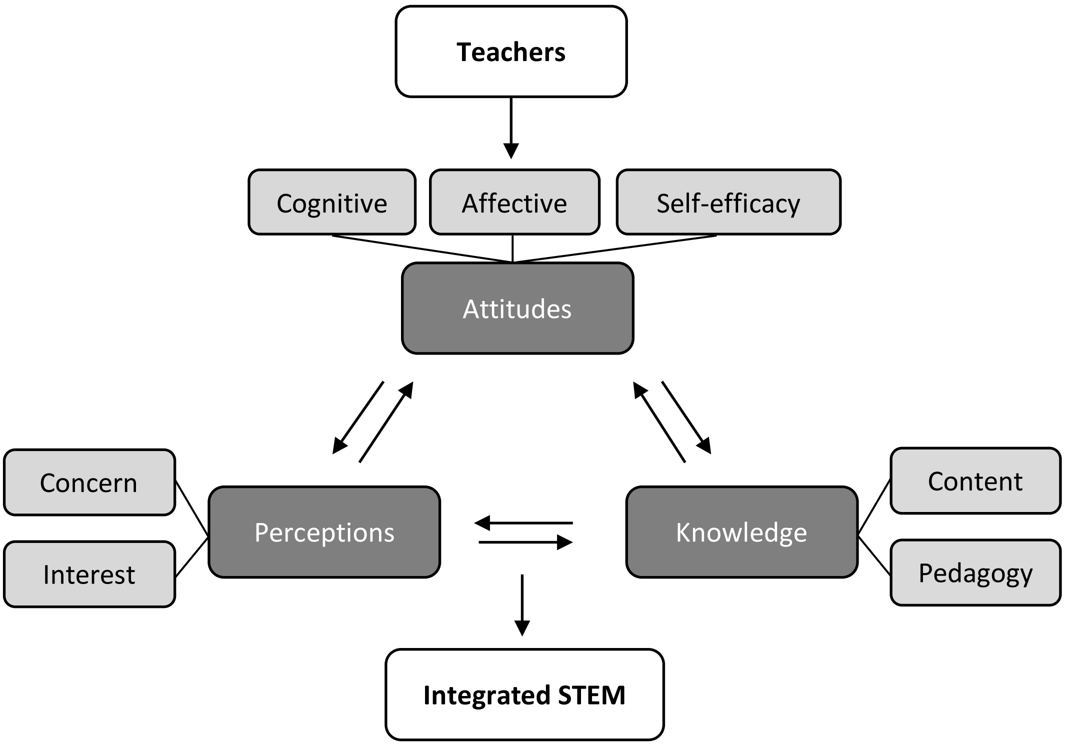

FIGURE 1. *Conceptual framework for teachers' attitudes, perceptions, and knowledge towards integrated STEM*

In the conceptual framework as shown in Figure 1, we used three domains of attitudes, perceptions, and knowledge of teachers to be constructed into seven sub-domains of teachers in STEM education in examining the relationship between the domain and sub domains aspects which could reflect on teachers' thinking and understanding towards integrated STEM. The findings of several researchers above, it indicated that teachers' attitudes, perceptions, and knowledge can be seen as their teaching experiences during their implementation towards integrated STEM disciplines.

METHODS

Research Design

This study used a cross-sectional survey design model to collect data from a sample of the target population which then further evaluate through various variables (Creswell, 2012). The survey reported an understanding of a wide range of users. This tool was used to collect data in a broad ranges, to explore the in-depth current situations, and to implement the logical thinking by the respondent. This design also able to describe the respondents' feeling and to address issues of credibility, consistency, and transferability (Gordon & McNew, 2008; Merriam, 2014). This design can describe measuring the current attitudes, perceptions, and knowledge of teachers related to integrated STEM by providing the information about what they think about the issues based on their experiences. To evaluate the variables of this study, we used the questionnaire as the instrument comprising of 10 multiple choices that explore the information of gender, age, teaching assignment (subject and level), teaching experience, and educational background. The questionnaire also consists of 40 multiple choices that has been developed based on the domains and sub-domains used in this study such as teachers' attitude (feeling, response, and belief), perception (concept learning, problem-solving, developmental, and differential focus), knowledge (propositional knowledge, case knowledge, strategic knowledge). Moreover, the questionnaire was designed by the researchers with the assistance of professional colleagues who have validated the instruments.

Research Instrument

The instrument in this research was the result of conducting several revisions based on the validator/experts feedback and the statistical analysis for the pilot study that used the sample size (N=37). This is based on the recommendation of Cochran (1963) who suggested that a sample size of the study should be more than 100 that can be considered to be used. The small sample size also can limit the number of parameters for the researcher who cannot explore the development scale to determine a total population as the sample size. The participants of this study consists of 185 respondents who took part in the whole study. Actually, we got 197 respondents but after using the data cleaning, we found that some of them filled out the questionnaire two times while some of the respondents did not finish answering the questions. The Introductory section of the questionnaire contained all of the information relating to the purpose of making the instrument, how to use the instrument, how to provide and calculate survey scores, and how to obtain data easily. The instrument used in this research is a type of questionnaire by adopting the Likert-scale rating from Riggs & Knochs (1990) with the starting point range from strongly agree, agree, uncertain, disagree, and strongly disagree. The given score begins from 5 for strongly agree, 4 for agree, etc. The scoring for every item used the calculation of 2 scales which is different for every respondent. The quality of the questionnaire had shown 0.80 - 1.00 of the item objective congruence, 0.40 - 0.77 of discriminatory power, and 0.94 of the reliability of Cronbach's Alpha coefficient. In short, this instrument constructed by the sub-dimensions of the test based on our conceptual framework in Figure 1 which consists of the cognitive, affective, self-efficacy, concern, interest, content, and pedagogy of integrated STEM. The example of the test components are: Implemented of STEM toward science/math teaching (SAt-Cg), Teaching with problem-solving (SAt-Af), Experience in science (SAt-SE), Teaching STEM disciplines (SPr-Cn), Teaching STEM approaches (SPr-It), STEM Competencies (SKw-Ct), STEM teaching and learning (SKw-Pd).

Research Population and Sample

This research was conducted amongst 185 Indonesian teachers from elementary, middle, middle schools, and private educational institutions from the eastern, western, and central regions of Indonesia. The participants have various ethnicity and were asked to voluntarily participate in this study. The questionnaire were distributed online through some social media platforms. Theoretically, a survey can report the understanding of a wide range of participants that can explore what happens in the current situations, the ability to implement logical thinking, and describe their feeling including to address issues of credibility, consistency, and transferability (Gordon & McNew, 2008; Merriam, 2014). The information of demographic data of the participants can be seen in table 1.

Table 1. *Demographic data information of the participants in the study*

Variable	Category	Quantity	Percentage (%)
Gender	Male	44	23.78%
	Female	141	76.22%
Ethnic and Culture	Sunda	61	32.97%
	Java	48	25.95%
	Malay	28	0.54%
	Other	48	25.95%
Age	Under 20 years old	20	10.81%
	20 to 30 years old	129	69.73%
	31 to 40 years old	22	11.89%
	41 to 50 years old	6	3.24%
	Above 50 years old	8	4.32%
Degree	High School	48	25.95%
	Bachelor	108	58.38%
	Master	27	14.59%
	PhD	3	1.62%
Teaching Experience	Less than 1 year	89	48.11%
	1 to 5 years	55	29.73%
	6 to 10 years	21	11.35%
	11 to 15 years	9	4.86%
	More than 15 years	11	5.95%
Institution	Public School	88	47.57%
	Private School	57	30.81%
	Non Formal School	18	9.73%
	Indonesian Foreign School	4	2.16%
	Other	18	9.73%
Area of Specialization	B.Ed (Science or Math)	140	75.68%
	B.Sc (Science or Math)	10	5.41%
	M.Ed (Science or Math)	22	11.89%
	M.Sc (Science or Math)	3	1.62%
	PhD	3	1.62%
	Other	7	3.78%
Subjects	Science	28	15.14%
	Biology	63	34.05%
	Chemistry	60	32.43%
	Physics	14	7.57%
	Math	8	4.32%
	Technology	2	1.08%
	Engineering	2	1.08%
	Other	8	4.32%

Based on table 1, it is clear that from 185 participants, 44 were male and 144 were female. All of these participants came from different ethnicities and cultures with the highest contribution was 61 participants from Sunda and the lowest contribution was 28 participants from Malay. However, there are also Indonesian teachers from the eastern, western, and central regions of the country who also took part in this study. Furthermore, participants' ages in this study were around 20 to 30 years old (129 participants) as the biggest contribution, while the lowest contribution support was 6 participants with the range of age of 41 to 50 years old. Besides, the majority of participants hold a bachelor's degree (108 participants), and only a few of them hold master's degrees and Ph.D. Moreover, the participants consisted of 179 teachers who also hold a different background position. There were 89 participants have teaching experiences at less than 1 year as the highest contribution in this research while 9 participants have 11 to 15 years teaching experiences. Moreover, they came from 88 public schools, 57 private schools, 4 Indonesian foreign schools, and 18 non-formal schools. Talking further, their area of specialization of study consists of 140 B.Ed., 10 B.Sc., 22 M.Ed., 3 M.Sc., and 3 PhD. However, all of them hold the area of specialization in science and math in which there were 28 science teachers, 63 Biology teachers, 60 Chemistry teachers, 14 Physics teachers, 2 Engineering teachers and 8 Mathematics teachers. These findings indicated that 117 participants have known the term of STEM education and 68 participants did not know the term.

Data Collection and Analysis

In this study, data were collected using a questionnaire that has been developed by the researchers based on the literature and the expert views. The first step of the questionnaire aims to explore the respondents' demographic data with a total of 10 questions and 40 items to look for teachers' attitudes, perceptions, and knowledge regarding integrated STEM education. The example of this items consist of "ethics where the teachers come from the range of teachers' teaching experience". The second part of the questionnaire consists of the multiple-choice to explore the items, with a total of 40 questions, where we used the Construct Validity. The example item to get information about teachers' STEM attitudes was "I agree to implement science, mathematics, technology and engineering approaches in teaching science in the classroom". Next, an example item to elicit information about teachers' STEM perception was "I want to know more about science, technology, engineering, and math that is why I want to learn about STEM education". Finally, the sample item to get information regarding STEM knowledge was "I know that STEM is a combination of Science, Technology, Engineering, and Mathematics". While accessing the questions model of STEM, we used the opinions and obstacles or challenges of the implementation of STEM. For instance, "based on your current knowledge and abilities, please provide some agreement about integration of STEM subjects in the classroom". The participants were given enough time to read the information before filling out the form. The complete form of core items regarding teachers' attitudes, perceptions, and knowledge by the participants of the final instrument is shown in the appendix I of this paper. However, the validity of content is extended to extend so that the instrument measures all facets for giving a social construct, in case of essential skills for scientific fields.

Measuring content validity is included in building on national reports and the survey about essential skills for scientific education as well as STEM education and utilizing from the expert validator. For example, in the domain of general information, the validator 1 said that there is a need to insert the word "other" in the degree and the subject of the participant. Meanwhile, the validator 2 said that there is a need to change the sentence in the general agreement before continuing to the questions. Furthermore, validator 3 said that we need to check the questions section about asking the teachers' experience. However, the construct of validity can be involved in statistical analyses and evaluating the item validity, in avoiding bias and relationships between instrument items. This validity process was conducted to see how the instrument looks and expose the content or appearance. Moreover, analyzing the level of instrument reliability was done after obtaining the data on the result of the respondents' tests results using Cronbach's Alpha method. Then, the Reliability of statistics was showed by Cronbach's Alpha = .940 from the sample of 40 items test in which measurement tools can be trusted. The data in this research conducted in several steps to analyze, and interpret the data of mean values and standard deviations. The Kolmogorov Smirnov test was examined to find the compliance of the variables a normal distribution as a significant relationship between the variables tested (Hinkle, Wiersma, & Stephen, 2003). The relationship between attitudes, perceptions, and knowledge towards integrated STEM was calculated to descriptive statistics (utilizing Microsoft Excel and SPSS version 23). The Spearman's correlations test as the non-parametric test was used to determine the normal distribution to know whether the correlation of the strength and the weakness of the correlation that Evan (1996) suggested to the absolute value r =.00 - .19 which refers to relationship it is "very weak", .20 - .39 "weak", .40 - .59

"moderate", .60 - .79 "strong", .80 - 1.0 "very strong. However, in the statistical test, this was used to decide the level of p<0.05 that has been accepted as the indicator of difference.

RESULTS

Descriptive Data on Each STEM Domain

This section presents findings of the descriptive statistics (mean scores and standard deviations) of the survey and also the components and sub-components of each item grouped into the domain of integrated STEM. The five-point Likert-scale applied starts from the smallest value (1) to the highest (5) for every question items.

Table 2. *Components and sub components of STEM domain*

Components	Sub Components	Mean	SD
STEM Attitudes (SAt)	Cognitive	3.82	0.86
	Affective	3.72	0.79
	Self-Efficacy	3.29	0.86
	Average	3.61	0.84
STEM Perceptions (SPr)	Concern	3.49	0.71
	Interest	3.72	0.78
	Average	3.61	0.75
STEM Knowledge (SKw)	Content	3.75	0.93
	Pedagogy	3.53	0.79
	Average	3.64	0.86

Table 2 showed mean scores and standard deviations of each component (attitudes, perceptions, and knowledge of STEM) and sub-components (cognitive, affective, and self-efficacy of STEM attitudes, concern, and interest of STEM perceptions, and the content and pedagogy of STEM knowledge). The mean scores for all components and sub-components of the STEM domain ranged from 3.29 – 3.82. Furthermore, the average mean scores and standard deviations of each STEM domain is (M=3.61, SD=0.84; M=3.61, SD=0.75; M=3.64, SD=0.86). However, the components with the highest scores in the STEM attitudes (SAt) were the cognitive sub-components (M=3.82, SD=0.86) and the sub-components with the lowest scores were self-efficacy (M=3.29, SD=0.86). Another finding in the highest scores of STEM perceptions (SPr) components was the interest sub-components (M=3.72, SD=0.78) but the lowest scores were the concern sub-components (M=3.49, SD=0.71). The late findings showed in the components of STEM knowledge when the highest scores were the content sub-components (M=3.75, SD=0.93) and the lowest the sub-components of scores were the pedagogy (M=3.53, SD=0.79).

Relationship between Attitudes, Perceptions, and Knowledge

To investigate the relationship between each integrated STEM variable in this study, we used the testing of Spearman's correlations coefficient test to find the significant relationship between attitudes, perceptions, and knowledge of teachers. Table 3 presents the Spearman's correlations coefficients that we have found between attitudes, perceptions, and knowledge of teachers. Evan (1996) suggested that the interpretation of correlation coefficients has to show the significant relationship (r) between variables with the strength or weakness of the relationship to be a positive and negative. The Spearman's correlations test value between the three components and the seven sub-components of attitudes, perceptions, and knowledge showed that significant relationship in the level of 1 or (p< .05). Moreover, it could be concluded that indicating relationship between attitudes and perceptions is negative, perceptions and knowledge are negative, attitudes and knowledge are positive relationships. However, the Kolmogorov Smirnov test results showed that K-S test = 0.2 indicates the variables as a normal distribution that a significant relationship between the variables tested (Hinkle, Wiersma, & Stephen, 2003). This result showed that teachers' attitudes were significant with r=1.00 which means positive and strong, teachers' perception with r=-.257 which means negative and weak, teachers' knowledge with r= .886 correlated with integrated STEM. For instance, teachers who have attitudes and knowledge are involved in teaching integrated STEM course, usually do not have perceptions in teaching.

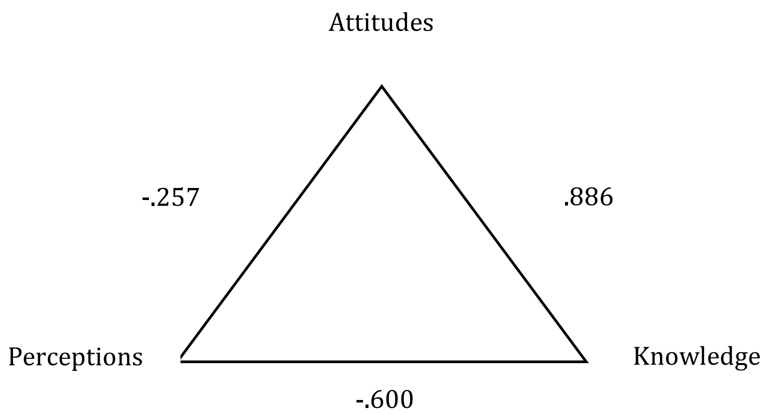

FIGURE 2. *The correlation coefficient between teachers' attitudes, perceptions, and knowledge*

Correlation is significant at the 0.05 level (2-tailed)

The Differences between Teachers' Attributes Compare to the Demographic Data, Namely Gender, Teaching Experience, Area Specialization, and the Subject of Teachers

To allow readers to follow and interpret our results, we also present the differences in teachers' attributes compared to demographic data of all subscales of gender, teaching experience, area specialization, and the subject of teachers. It was considered to be a predictor variable, while attitudes, perceptions, and knowledge were adjusted as the dependent variable. The intention of calculating this effect equation was to identify which component has the most influence.

Table 3. *The differences between teachers' attitudes, perceptions, and knowledge compared to demographic data*

Components	Namely	Beta	p<0.01	R	R Square
Teachers' attitudes, perceptions, and knowledge	1 (Constant)			.090	.008
	Gender	.005	.943		
	Experience	.050	.512		
	Area	-.092	.256		
	Subject	.027	.741		

** Correlation is significant at the .05 level (2-tailed)*
*** Correlation is significant at the .01 level (2-tailed)*
Values indicate significance at p<0.05 level

Meanwhile, it has a significant impact on attitudes, perceptions, and knowledge can be seen in table 3 about three predictor components, such as gender, teaching experience, area specialization, and subject. In the model, the summary indicated that three variables showed a positive relationship with teachers' attitudes, perceptions, and knowledge, i.e. gender, teaching experience, and subject. However, one variable is negatively linked: an area of specialization. In summary, teaching experience, and the subject had a linear relationship with teachers' attitudes, perceptions, and knowledge. Moreover, R and R Square showed the impact of each variable can give the simultaneous contribution to the factor predictors. Furthermore, regarding the components, data analysis showed the regression analysis obtained results.

DISCUSSION and CONCLUSIONS

The relationship between teachers' attitudes, perceptions, and knowledge towards integrated STEM: It can be observed by the investigation of Spearman`s Rho test to see the relationship between three variables. This test only explains the strength of the relationship and also whether or not there is a significant relationship amongst the level of attitude, perception, and knowledge of teachers. The testing of Spearman's correlations coefficient was done to find the significant relationship between attitudes, perceptions, and knowledge of teachers are presented in figure 2. As the result, the Spearman test correlations values of these variables showed significant relationship in the level of 1 or ($p< .05$) between teachers' attitudes and their knowledge. This indicated as the strong correlation between each other's where teachers who had better content and pedagogical knowledge of integrated STEM also have a good positive attitude of cognitive, affective, and self-efficacy towards. Moreover, the relationship between attitude and knowledge was found as a high relationship level. This finding coincides with the results of a research conducted by Dyehouse et al (2015) who found the weak correlations between teachers' attitudes and their knowledge. These results showed a moderate correlation between each variable. However, these results also indicated that teachers have better knowledge because the regularity of integrated STEM in daily learning is more than their attitudes during implementation. As noted by Lieflander et al (2016), knowledge can be indicated by teachers' strength and scientific understanding of integrated STEM rather than unpredictable attitude in daily teaching. Furthermore, these results also found a weak relationship between knowledge and attitudes. However, an analysis of our results showed that teachers who have attitudes and knowledge involved in teaching integrated STEM courses, usually, do not have perceptions in teaching. These results have a similarity with Wahono & Chang (2018) when they examined the relationship between teachers' knowledge, attitudes, and application toward STEM education. The finding was a positive relationship between teachers' attitudes and knowledge from examining 124 science teachers who describe that they have better attitudes and knowledge. Moreover, Evans and Durant (1995) explained that attitude structures and knowledge concepts have a relationship between one other through a scientific understanding and general or specific attitudes.

The differences between teachers' attributes could be compared by looking at the demographic data, namely gender, teaching experience, area specialization, and the subject of teachers. By the results, we considered that some aspects related to teachers' attributes can affect the integrated STEM teaching in the classroom. Likewise, Al Salami et al (2015) found that gender, school, education level, and discipline experiences can impact the teachers' attributes in which it could make them have more positive teaching, willingness to work in a teamwork, and satisfaction during participation and show less positive response activities. Similarly, Thibaut et al (2017) found that teachers who have a good personal background characteristic can provide a positive correlation with their attributes. For example, a good attitude can affect high professional development towards an integrated STEM teaching. Furthermore, they have a greater emphasis on facilitating the school context of environmental factors related to a resource and allocate time during teaching and learning. Moreover, in this research, we used the demographic data information of the participants in which there were 141 respondents were identified as female with a ratio of 76.22%, while 44 males also have participated in this study with a ratio of 23.78%. Also, statistical results showed that the highest ethnic and cultural contribution of this survey was32.97% from Sunda, 25.95% from Java, and 0.54% from Malay. While the age of most respondents was around 20 to 30 years old with a ratio of 69.73% has filled out the questionnaires. Meanwhile, 108 teachers who have participated in this research have a bachelor's degree with a ratio of 58.38%. Talking further, around 47.57% (88 teachers) in this study come from public schools while 57 teachers come from private schools (30.81%).

Besides, the significant predictor factors have been analyzed to compare the gender, teaching experience, and area specialization, the subject that affects teachers' attitudes, perceptions, and knowledge of integrated STEM. This prediction may help instructors to observe the barriers in introducing a new and potentially controversial topic of demographic information. Several researchers have already confirmed that case. For example, Thibaut et al (2017) reported that the demographic information of teachers who have a good personal background characteristic can provide a positive correlation with their attitudes. Al Salami et al (2015) found that teachers' gender, education level, and teaching experience give the correlation as a positive attitude. Moreover, Wang et al (2011) pointed out a case of teachers' perceptions towards integrated STEM that have strong result in their area and design of teaching based on the process of STEM integration unit. Similarly, Park et al (2016) also found that teachers with the area of specialization can have a positive view of perceptions towards STEM education when they compared 2 levels kind of school teachers in their country. As mentioned by Aldahmash et al (2019), they noted that teachers came from different background face a lack of conception about STEM and do not understand how to integrate it. Consequently, teachers' views and beliefs in a core concept can be influenced by the teachers' activities in teaching (Nathan & Koedinger, 2000; Yasar et al., 2006). Some interesting findings, as noted by Radloff & Guzey (2016) showed that teachers' conceptions can affect their understanding of STEM content and practices in their teaching. While Dare et al (2019) described that teachers' competencies can be learned and implemented in the thinking and understanding toward integrated STEM.

From the results of this study, we argue that the impact of teachers' attitudes, perceptions, and knowledge has two reasons as presented in table 4. First, the gender, teaching experience, and subject had a positive effect on teachers' attitudes, perceptions, and knowledge of integrated STEM. As noted by Margot & Kettler (2019) who suggested that variation of teachers' gender, experience, and area specialization may influence their support and enthusiasm for the school to develop STEM initiatives. Teachers look to perceive interdisciplinary STEM initiatives as a challenge of teachers' beliefs to grow up in high-quality teaching for their students. This could be done by removing the barriers in teachers' habits such as in the pedagogy, curriculum, assessment, or evaluation. Hence, teachers can be prepared their students in their future careers through supporting and facilitating their students by opening students' mindedness and understanding of learning towards integrated STEM (Nadelson & Seifert, 2017).

Most of the participants in this research are female with a ratio of 76.22% or around 141 respondents while males who took part in this study were lower with a ratio of 23.78% or 44 respondents. It may remove the barriers and perspective according to Chavatzia (2017) reported that female's education in STEM is low in quantity, which about only 35% of STEM students in higher education globally, and differences are observed within STEM disciplines. Our results indicate that female has more interest in STEM education than male. However, Witherspoon et al (2016) found that female has a gap in the learning environment in which female has been shown slowly enhanced participation in competitions than male. Female was generally less involved in the experience than male in attributing the success in their abilities. It will affect to address gender imbalances in particularly curriculum and pedagogical characteristics. Furthermore, Dyehouse et al (2015) explained that gender may take male teachers than female teachers longer to change their mind-set related to integrate STEM as measured by cognitive rigidity. Moreover, female teachers may find it easier to get pressure in response to change measured by the emotional reaction to imposed change. Furthermore, teachers' experience can be learned and developed by the teaching practices. As noted by Thibaut et al (2017) who found that teachers experience has a correlation with teachers' attitudes when they participate in a professional development. It might be linked to their variables in positive or negative attitudes. Moreover, all background characteristics will make the variation in teachers' attitudes. Another way to support teachers' experience is by conducting systematic and high quality professional development (Guzey et al., 2014; Brophy et al., 2008; Roehrig et al., 2012), pedagogical development can influence teachers' understanding, thinking, and facilitating their teaching for acquiring knowledge related to new teaching practices or contents (Estapa et al., 2016). However, these results expose the interest findings that most of the teachers have to teach two or more subjects in the classroom but their subjects were related to specification are teachers graduation was correlated with their teaching. In similar vein, Masoka et al., (2017) reported that 71% of junior and senior high school teachers matched with their subject even though they taught a subject which related to their specialization areas.

The second thing is about the area of specialization of the teachers which may influence the attitudes, perceptions, and knowledge of integrated STEM. As mentioned by Breiner et al (2012) who described that many teachers failed to determine an understanding of STEM terms. It may affect the students learning and their decision toward their future careers and interests. While Vossen et al (2019) suggested that it is important for the teachers to add professional learning development, especially for the teachers in non-science subjects and beginning to teach as well in STEM subjects. However, the outcomes of this study showed that it is important to provide the teachers with professional development skills through training that can enhance their teaching towards integrated STEM. The government need to give such training in development skills for all school teachers from the eastern, western, and central regions of Indonesia without exception to teachers coming from different subjects and school level that mentioned in this research.

SUGGESTIONS

There are some suggestions for the future study that were offered after conducting this research:

1. From the results of this research, we found a positive correlation between attitudes and knowledge of Indonesian teachers. However, Indonesian teachers still showed negative perceptions towards integrated STEM. We suggest that it will be better to study more comprehensive and add some more domains related to STEM education. It is hoped that teachers can learn more related to their attitudes, perceptions, and knowledge towards integrated STEM and take the opportunity when they have to learn STEM education in their country.
2. From the results of this research, we expect science teachers, other researchers, or policymakers in the field of education to learn or support teachers in their learning and teaching related to professional development. It can help to expose their understanding, thinking and facilitate teachers learning. It is better to provide opportunities for teachers to acquire knowledge related to new teaching practices or content of STEM education.
3. From this research, we have focused on three-domain components of teachers' attitudes, perceptions, and knowledge and also sub-components of cognitive, affective, self-efficacy, concern, interest, content and pedagogy of integrated STEM. For future research, we hope that researchers will elaborate further on the component domain or sub-components related to current problems faced by teachers towards integrated STEM.

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APPENDIX I

Phase 1: General Information

On this phase, participants will be asked to fill out the online survey related to gender, age, teaching assignment (subjects and level), teaching experience, and educational background of participants. In accordance with the initial idea of the research, the participant's identity will be disguised.

Do you know about STEM learning? If yes, please provide the information below.
- Yes, please continue.

Gender:
- Male
- Female

Ethnic:
- Sunda
- Jawa
- Other

How old are you:
- Under 20 years old
- 20 to 30 years old
- 31 to 40 years old
- 41 to 50 years old
- Above 50 years old

What is your degree:
- High School
- Bachelor
- Master
- Doctoral
- Other

How long have you been working as a teacher:
- Less than 1 year
- 1 to 5 years
- 6 to 10 years
- 11 to 15 years
- Above 15 years

What kind of school do you work?
- Public School
- Private School
- Indonesian Foreign School
- Non Formal School
- Others

What is your major or field?
- B.Ed (Science or Math)
- B.Sc (Science or Math)
- M.Ed (Science or Math)
- M.Sc (Science or Math)
- Ph.D
- Other

What subjects do you teach or other subjects?
- Science
- Biology
- Chemistry
- Physics
- Math
- Technology
- Engineering
- Other

Phase 2: Core Question

On this phase, participants will be asked to fill out the online survey related to teachers' instruction and teachers' attitudes (feeling, response and believe), perceptions (concept learning, problem solving, developmental and differential focus), knowledge (propositional knowledge, case knowledge, strategic knowledge) when teaching in general to the students.

The purpose of this questionnaire is to understanding your confidence about your ability to teach science, math, tech, and engineering in your school/institution to enhance your students in learning STEM education.

Please tick "√" to each statement and answer that the best describes in your belief and confidence.

Using the scale provided, how can you be consistent about your thinking of your the behaviors during your teaching.

DIRECTIONS:

For each of the following statements, please indicate the degree to which you: **"1" = Strongly Disagree, "2" = Disagree, "3" = Uncertain, "4" = Agree, "5" = Strongly Agree.**

Even though some statements are very similar, please answer each statement. There are no "right" or "wrong" answers. The only correct responses are those that are true for you.

Operational Definitions of STEM Components

Components	Sub Components		STEM Description/Aspects	Item
STEM Attitude (SAt)	Cognitive	a)	Implemented of STEM toward science/math teaching	1, 2
		b)	Integrated of STEM through design thinking toward science/math teaching	3, 4
		c)	Exposed to STEM disciplined toward science/math teaching	5, 6
	Affective	a)	Teaching with problem solving	7, 8
		b)	Teaching with design thinking	9, 10
		c)	Teaching with technology tools	11, 12
		d)	Teaching with engineering design	13, 14
	Self-Efficacy	a)	Experience in science	15, 16
		b)	Experience in technology	17, 18
		c)	Experience in engineering	19, 20
		d)	Experience in mathematic	21, 22
		e)	Experience of teaching STEM	23, 24
		f)	No have experience about STEM	25, 26
STEM Perception (SPr)	Concern	a)	Teaching STEM disciplines	27, 28, 29, 30
	Interest	b)	Teaching STEM approaches	31, 32, 33, 34
STEM Knowledge (SKw)	Content	a)	STEM Competencies	35, 36, 37
	Pedagogy	b)	STEM teaching and learning	38, 39, 40

The Components of STEM Education Survey

No	Statement	Components
1	I teach STEM since I know that it is related to my subject and knowledge	SAt-Cg
2	I'm continually improving my teaching practice to teach my students using STEM activities	SAt-Cg
3	I agree STEM education preparing the student's career and changing their thinking and learning	SAt-Cg
4	I agree to implement science, mathematics, technology and engineering approaches in teaching science in the classroom	SAt-Cg
5	I prepare the student in the co-curricular activities according to their abilities and interests related to STEM	SAt-Cg
6	I always prepare myself to learn about STEM education through workshop activities and by reading the articles	SAt-Cg
7	I'm confident and able to ask the questions to my students based on the phenomenon or define a problem that needs to be solved in my classroom	SAt-Af
8	I usually teach science/math content using problem-solving in STEM learning activity	SAt-Af
9	I believe the students do not have the ability to create their own thinking about STEM approaches because they do not have enough knowledge about it	SAt-Af
10	I surely agree to design the students thinking using STEM approaches	SAt-Af
11	I teach science/math content using a technology tool to help understanding a context simultaneously	SAt-Af
12	I agree that to teach the students, needs the technological tool especially in the learning of STEM	SAt-Af
13	I am pretty sure that we need to use the engineering design to teach the students which also can help the teachers	SAt-Af
14	I believe I can create a living class atmosphere when I use the engineering design into STEM activities	SAt-Af
15	I have the experience to teach science in the classroom but not using STEM teaching	SAt-SE
16	I find it difficult to help the students learning about science because of the	SAt-SE

	misinformation, they have learned from the parents, media, and other sources	
17	I have the experience to teach engineering in the classroom but not using STEM teaching	SAt-SE
18	I find it difficult to help the students learning about engineering because of misinformation, they have learned from the parents, media, and other sources	SAt-SE
19	I have the experience to teach technology in the classroom but not using STEM teaching	SAt-SE
20	I find it difficult to help the students learning about technology because ofmisinformation, they have learned from the parents, media, and other sources	SAt-SE
21	I have the experience to teach mathematics in the classroom but not using STEM teaching	SAt-SE
22	I find it difficult to help students learning about mathematic because of misinformation, they have learned from the parents, media, and other sources	SAt-SE
23	I know about STEM and I have the experience to teach it because I understand about STEM education	SAt-SE
24	I have ever come to STEM workshop and STEM activities about how to teach the students and share the knowledge with other teachers	SAt-SE
25	I do not know STEM and I do not have any experience to teach because I do not understand STEM teaching and learning	SAt-SE
26	I have never come to STEM workshop and STEM activities but I have ever read and known what STEM teaching and learning is	SAt-SE
27	I always think about the strategies to manage my class, especially in difficult moments when I teach STEM	SPr-Cn
28	Sometimes I feel uncertain about my ability to guide my students to select useful information for supporting their STEM learning	SPr-Cn
29	I don't think that STEM can improve students' conceptual understanding of science, math, engineering or technology	SPr-Cn
30	Sometimes I don't know how to teach my students to distinguish between data and the explanation when I teach STEM in my classroom	SPr-Cn
31	I feel confident with my ability to teach STEM to my students' about what and how is it	SPr-It
32	I want to know more about science, technology, engineering, and math that is why I want to learn about STEM education	SPr-It
33	I feel confident to find the strategies to encourage my students to feel able to do STEM activities	SPr-It
34	I believe and able to build the explanations about a phenomenon or design the solutions for a problem using STEM activities	SPr-It
35	I know the term of STEM	SKw-Ct
36	I know that STEM is a combination of Science, Technology, Engineering, and Mathematics	SKw-Ct
37	I know that STEM learning is suitable to my context and I can teach science effectively and I feel confident about my ability in guiding students to have the awareness about the source of evidence as a scientist	SKw-Ct
38	I'm confident and able to ask the questions to my students based on the phenomenon or define a problem that needs to be solved in STEM teaching and learning	SKw-Pd
39	I know the steps needed to teach science using STEM learning and STEM-related to a science project, project-based learning, and integrated science and mathematics to teach the students	SKw-Pd
40	I believe and able to use a variety of teaching approaches or strategies to develop the mathematics/science/technology/engineering concepts in STEM teaching and learning	SKw-Pd

Thank you for your participation!