



Perception and Motivation of Female and Male Students Toward STEM in Indonesia

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Abstract

The aim of this research is to find out the differences of male and female lower secondary school students on the aspects of perception, motivation, and interest in the field of STEM. The sample of this study consists of 370 middle school students in various province in Indonesia who had experience in STEM learning with teacher who had participated SEAQIS STEM training. The instrument used in this study was five scales Likert of SEAQIS STEMs Survey (SS-STEMs), which cover perception and motivation toward Science, Technology and Engineering as well as Mathematics. The instrument was validated by Rasch Model approach using Winstep v 3.7 and was found that it compatible with the model. Data analysis was conducted using the IRT Rasch model approach assisted by Winsteps Application ver 3.7. It was found that: (1) There is a significant difference between male and female students in the aspects of perception toward mathematics subjects; (2) There is no significance difference between male and female students in the aspects of motivation towards all subjects.

Keywords: Gender, Motivation, Perception, STEM

Introduction

Science, Technology, Engineering, and Mathematics (STEM) has been a SEAQIS concern in developing and improving teachers' competencies since 2015. In its implementation, SEAQIS conducts training annually to improve teachers' competencies in integrating STEM learning in the Current National Curriculum. This gives an impact on improving the quality of classroom learning, based on students' products, such as smart watering systems, palm seeds processor and activated charcoal from candlenut skin waste. In principle, the products that have been developed by students have not provided a specific description of how students are involved and students' interests in STEM learning or even in STEM careers. Because actually, as Aschcraft, McLain, and Eger (2016) stated that student involvement in a

group can be associated with a level of collective intelligence.

Although the prospect of the STEM industry is quite promising in the future, there are still challenges in attracting female professional workers to work in the STEM industry. In another study, it is stated that increased participation of women, not only in the field of STEM, had a positive impact on the economy as a whole (Duflo, 2012). Pusat Statistik Nasional (Statistics Indonesia, 2010) data shows that there are around 131.58 million workers available in the domestic labour market. Based on gender comparison, women's participation rates are around 35% while only 30% out of it are female workers in STEM industry. This is in line with the findings of Taylor and Valerie (2016) that shows although students do not have significant differences in mathematical and scientific abilities, they have differences in

interests and confidence in the STEM field (computer science). Most female students choose to enter psychology, biology and social sciences majors when entering the tertiary level education. When compared with male students, only 19% of female students majored in engineering, or about 4 times lower than male students (81%) (National Science Board, 2018). Student involvement in learning, not only STEM, is influenced by perception (Syaripah, 2016) and motivation (Saeed & Zyngier, 2012; Hoffman, 2015; Vero 2017).

Students' attitudes toward STEM are an important factor influencing student motivation to learn STEM subjects and pursue a STEM career. While there has been considerable research conducted about student attitudes toward science (Osborne, Simon, & Collins, 2003) and mathematics (Elci, 2017), there is less research available about female students' perception and motivation in the STEM field.

Integrated STEM classroom approaches are used in Indonesia, as STEM education is not particularly described and integrated in the curriculum. Yet, less attention has traditionally been paid to study STEM integration in National Curriculum and its effect on students' perception and motivation in the field of STEM including whether there are differences of the two aspects of girls toward STEM education subjects. Therefore, this research aims to find out Indonesian lower secondary school students' perception and motivation in each of STEM education subjects which are Science, Technology and Engineering as well as Mathematics, and to compare male and female in those two dimension.

While conceptions of what STEM entails vary among researchers, educators, and policy makers, there are two commonly accepted approaches to STEM education (Breiner, Johnson, Harkness, & Koehler, 2012; Sanders, 2009). The first approach, traditional STEM education, views STEM as four separate fields taught as traditional disciplinary courses. The second approach,

integrated STEM education, "includes approaches that explore teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects" (Sanders, 2009). Importantly, the National Academies of Engineering views engineering as a critical component of integrated STEM education and encourages K-12 teachers to use engineering as a vehicle to teach science, mathematics, and technology concepts (NRC, 2011).

Much of the available research on student learning and teaching practices comes from both STEM-focused schools (schools were implemented the STEM education) as well as STEM classroom (STEM education was only carried out in specific subject). Those mode of STEM education implementation refer to a country which has not adopted STEM as National Policy in a shape of formal curriculum guidelines, but schools as their own initiatives started to adopt STEM education on a classroom level. This research was conducted in the context of ASEAN countries that adopting and adapting STEM education in their own unique national contexts.

Perception is an impression of an object that is obtained through sensing, organizing, and interpreting the object which is accepted by the individual; thus, it is a meaningful and integrated activity within the individual (Walgito, 2002:100). So stimuli from outside are received or absorbed by the five senses which are then organized and interpreted into something that has meaning for the individual. The perceptual process is an activity that is integrated within the individual, namely a unit of psychophysical activity within the individual. Therefore according to Davidof (1989) and Rogers (1965) in Walgito (2002) that perception is individual. What is in the individual will be actively involved in perception, because feelings, thinking abilities, individual experiences are different, so that in perceiving a stimulus may also be different. According to Asrori (2009) perception is an individual

process in interpreting, organizing and giving meaning to stimuli that come from the environment in which the individual is located which is the result of the learning process and experience.

According to Walgito (2002) there are three conditions for perception to happen, namely (1) the object being perceived, namely the object that causes the stimulus; (2) sensory organs as receptors to receive stimuli and sensory nerves as a means to transmit the stimulus to the center of the nervous system (brain); (3) attention which is the main step as a preparation for perception. Robin (2015) declared that factors which influence perception are individual, target or object (stimulus), and situation. These factors need more attention to create more positive students' perception. Learning activities need to accommodate students' characteristic as it effects their perception. In learning context, teacher, as a target, can present clear, interactive, and innovative learning materials which can help students to get adequate learning information. Whereas, situation becomes one of the factors by creating comfortable, pleasant, and conducive condition for student as an individual. It can encourage students to be actively involved in learning activities and to have successful learning experience.

Motivation is an effective factor that led human organism to behave and determines insistence and energy of humans' behaviours' (Sevinc, Ozmen, and Yigit, 2011). The term motivation comes from the word motive which can be interpreted as the strength found in the individual that causes the individual to act (Uno, 2017). Referring to Kast and Rosenzweig (in Pardee, 1990), motives are what drive a person to act in a certain way to at least develop a tendency for certain behaviours. Motivation can be defined as the forces within a person that encourage him to meet basic needs or desires. Motivation ultimately comes from the tension that arises when one or more of our important needs is not satisfied.

Motivation to learn can arise due to intrinsic factors, namely the will and desire to succeed as well as the encouragement of learning needs, expectations of ideals/ambition. Meanwhile, the extrinsic factors are the existence of appreciation, a conducive learning environment, and interesting learning activities. These two factors must be considered because it is certain stimuli which make them want to do more active and enthusiastic learning activities (Uno, 2017: 23).

The brains of women and men are more similar than different. The brain is very plastic and experience can modify its growth. Thus, biological factors do not really determine gender behavior and attitudes. It is the child's socialization experience that has more of an effect. The socialization view, both psychoanalytic theory and social cognitive theory, explains that social experiences affect children's gender development (Santrock, 2010). Gender differences in behavior and attitudes are more due to differences in social expectations and different treatment of boys and girls. According to Martin & Dinela (Santrock, 2010) the gender scheme theory states that individual attention and behavior is guided by internal motivation to adjust to gender-based socio-cultural standards and gender stereotypes.

Methods

This study used survey design and questionnaire as mean for collecting data. This research utilizes a 5-points Likert scale to measure students' perceptions and motivations toward STEM subjects. This instrument was developed through standard procedure in developing instrument and the instrument item (24 item) meets the criteria of Rasch model, illustrated by $0,5 < MNSQ < 1,5$ and $0,4 < \text{point measure correlation} < 0,85$ (Boone et al., 2014) and has R value of 0.93 which was categorized as high reliability. The respondent are 370 students (143 males; 227 females) from different cities in Indonesia. The students have participated in STEM learning by the teachers who had participated in SEAQIS STEM training. Data analysis was

conducted using the IRT Rasch model approach assisted by Winsteps Application ver 3.7 . Data analysis was carried out to classify students' motivation and perception towards STEM subjects into five scale using formula of mean \pm deviation standard (Syaifuddin, 2012) and to find out gender bias significance.

Results and Discussion

In order to find out the levels of perception and motivation of the students toward STEM subjects (science, technology & engineering, and mathematics), a 5-scales categorization was first made using the formula as shown on table 1 as explained by Syaifuddin (2012). This categorization was made for perception and motivation toward STEM subjects.

Table 1 Categorization of Students Perception and Motivation toward STEM Subjects

	Formula	Category
1.	$+1.5 \sigma < \mu$	Very High
2.	$+0.5 \sigma < \mu \leq +1.5 \sigma$	High
3.	$-0.5 \sigma < \mu \leq +0.5 \sigma$	Moderate
4.	$-1.5 \sigma < \mu \leq -0.5 \sigma$	Low
5.	$\mu < -1.5 \sigma$	Very Low

Note: μ : Mean; σ : Deviation Standard

Perception by Gender

According to the formulas on Table 1, which regards to the categorization of the responses on the perception and motivation of the respondents toward STEM subjects, these data were collected. It can be seen in Table 2

that both female and male students have high perceptions toward technology and engineering also have moderate perception toward mathematics. While female students have higher perception toward science than male students.

Table 2. Students' Perceptions toward STEM Subjects

Gender	Perceptions					
	Science		Technology & Engineering		Mathematics	
	Mean	Category	Mean	Category	Mean	Category
Female	0.73	High	1.71	High	-0.05	Moderate
Male	0.57	Moderate	2.22	High	0.04	Moderate
Significance	0.236		0,233		0.047	

Further, Table 2 also shows that, based on statistical test, the students' perceptions significance toward Science is 0.236 which can be concluded that there is no significant difference between male and female students in their perceptions toward Science. According to the data, the mean for female students is 0.73 while for male students, it is 0.57. These numbers show that female students have more positive perceptions toward Science in comparison to male students. These results are in accordance with the study of Kaya, Kilic, and Akdeniz (2004)

who state that statistical result of the QPSC score undergraduates' perception of their science classes were significantly differ favouring female students in the grades of third year. Another possible explanation, that it is probably that science learning in middle school tend to has more focus on practicum activity as female students tend to have more interest in thorough and tenacious activities as they can be found in practicum activity. This finding is in line with a study by Kaya, Kilic, and Akdeniz, (2004) which states that female students better than male students on the

factors of interest in teaching, grades as feedback, and laboratory experiences, while male students were better than female students on only the factor of passive learning.

Further, the students' perceptions toward Technology & Engineering also show no significant difference between the perceptions of female students compared to male students as the significance being 0.233. Just looking at the mean, the perceptions of female students (1.71) is lower than that of male students (2.22), even though both of them were categorized as high. This translates to male students having a more positive perceptions toward Technology & Engineering in comparison to female students. It is caused by assumption which believes that technology and engineering are male stuff which then unconsciously affects teachers, parents, and people assumption (Madara and Namango, 2016). It is also supported by finding that female students have been less-related to information on technology and engineering. Furthermore, female students prefer to choose education, psychology, and health as their majors in university (Castillo, Grazzi, and Tacsir, 2014). Therefore, to attract more female students to technology and engineering are by creating engineer's resources and training opportunities to school counsellors and teachers which can be used to promote engineering education and careers to girls, their parents, and educators. (Madara and Namango, 2016).

As for the students' perceptions toward Mathematics, there is a significance value of 0.047. This value, is lower than 0.05, therefore a significant difference between the perceptions of male and female students toward Mathematics can be concluded. According to the mean, the perception value of male students toward mathematics is slightly higher compared to that of female students. This result is not that different with the findings of Mutodi, Paul and Ngirande, & Hlanganipai (2014), which stated that the results of their study is consistent with

another's findings by Hoang (2008), who showed that male consistently reported slightly more positive perceptions than female.

In the context of this study, the explanation for the result is that there is a possibility that STEM learnings which the students enrolled in were science-dominated. During the development of STEM projects, most of the issues dealt with are related to science. There is also the fact that in referencing the National Curriculum, the basic competencies for science were the main references, while basic competencies for mathematics serve only as prerequisites or as secondary references. This is due to the fact that in Indonesia, there are no STEM curricula, so that STEM was integrated into the National Curriculum. However, the National Curriculum itself was not designed for STEM learning, so it is not easy to find a topic that accommodate basic competencies in the courses of Science and Mathematics in relatively same or similar moment. Consequently, an alternative to this is by designating a course to be the leading sector, while the other becomes the prerequisite or as secondary materials.

Consequently, female students rarely get the opportunities to experience learning mathematics material positively. While, positive experiences are necessary toward positive perceptions, because individuals who experience an object or event positively tend to also have positive perceptions toward the object or event, and vice versa (Asrori, 2009). On the other hand, in the case of male students, less intensive material presentations are assumed to be sufficient for their learning, as shown by them scoring slightly higher compared to female students. It is supported by other studies, such as the one by Mutodi, Paul and Ngirande, & Hlanganipai (2014), who showed that the perceptions of male students are a bit higher compared to female students. They also stated that their study is consistent with findings by Hoang (2008), who showed that male students consistently

reported slightly more positive perceptions than female students.

Same result of statistics test was shown between female and male students' perception toward science also technology and engineering. This was indicated by significance value higher than 0.05 which mean no gender bias, which can be interpreted as there is contribution of STEM learning to provide balanced positive experience for female and male students which implies to decreasing of gender bias. Even though, both perception must be enhanced, especially for male students toward science and female students toward technology and engineering. In contrary, statistic test for perception of female and male students toward mathematics show significance which indicate there is gender bias to be handle moreover the value of both mean are still categorized as moderate.

Therefore, to increase the perceptions of male students toward science, female students toward technology and engineering, moreover both female and male students toward mathematics, and to make STEM learning more comprehensive, collaborative STEM learning between science, mathematics, and technology teachers need to be considered. Lesson learnt from teachers who conducted on the job learning using STEM Local Context (SEAQIS, 2019) indicate that making use of local issues where the school is situated can also help teachers and students find suitable topics for STEM learning easier. With respect to time allocated for them in the curriculum, it is worth considering the use of the school projects approach, extracurricular activities, or any other activities that the school condition

allows for. Robin (2015) declared that factors which influence perception are individual, target or object (stimulus), and situation. These factors need more attention to create more positive students' perception toward science and technology and engineering. Learning activities need to accommodate students' characteristic as it effects their perception. In learning context, teacher can present clear, interactive, and innovative learning materials which can help students to get adequate learning information. Whereas, situation becomes one of the factors by creating comfortable, pleasant, and conducive condition for student as an individual. It can encourage students to be actively involved in learning activities and to have successful learning experience.

Motivation by Gender

Table 3 shows the motivations of male and female students toward Science and Technology & Engineering scoring equally on the High category. Considering the mean value, female has higher score in science but lower score in technology & engineering. This is in line with other studies which claim that female students' motivation in science level is higher than male (Yilmaz and Cavas (2007); Sevinc, Ozmen, and Yigit, 2011; Chan and Norlizah (2017)). On the other side, they have moderate category in motivations toward mathematics. This is also in line with several studies which show the same result (Frenzel, et. al. 2010), and even Nosek, Greenwald, and Banaji (2002) who claim that in university level, women are poorly represented in math and math-intensive field such as the physical science, math/computer science, and engineering. This happened because of stereotype.

Table 3. Students' Motivations toward STEM subjects

Project Gender	Motivations					
	Science		Technology & Engineering		Mathematics	
	Mean	Category	Mean	Category	Mean	Category
Female	2.16	High	3.88	High	0.34	Moderate
Male	1.86	High	4.49	High	0.42	Moderate
Significance	0.259		0.083		0.543	

In the context of this study, the high motivations toward Science and Technology & Engineering along with the ordinary motivations toward mathematics, is possibly due to the fact that STEM learnings which the students enrolled in were Science-dominated; as is the case with the students' perceptions dimension as explained before. Further, the high motivations of students learning in Technology and Engineering can be attributed to the fact that the STEM projects they were involved in were heavily related to Technology & Engineering. It can be said that those projects, being one of the cores in STEM learnings, contrast them with other project-based learnings. For every STEM project, each team is assigned to solve real problems/issues happening around them. From the report of On the Job Learning (OJL) of teachers who participated in SEAQIS STEM Local Context training, it was found that the results of STEM learning observations are in line with the students' interviews after participating in them, in which they mostly said that they enjoy STEM learning and were happy in being able to solve problems/issues in the STEM projects (SEAQIS, 2019). This is further supported by the motivational theory, in which it says that the factors that increase students' motivations include a learning where they were given the opportunities to try, participate, and feel accomplished. This feeling of accomplished will rouse their learning motivations (Sukmadinata, 2011).

Table 3 also shows the significance values, acquired from the comparative test between the motivations of male and female students toward the three STEM subjects, where all the values are higher than 0.05. Therefore, the gender-based differences regarding motivations are not significant. This can be assumed that through STEM learning, teachers are able to increase relatively equal motivations between male and female students which decrease gender bias. Even though the motivations toward Science and Technology & Engineering are high, improvement is needed to work on the students' motivations toward Mathematics.

Another possible explanation is that the brains is very plastic, in which experiences can modify its growth for example socializing experiences of the students which can significantly determine gender behaviours and attitudes (Santrock, 2010). From the context of Santrock's explanations, it can be concluded that teachers need to consider to provide their students with socializing experiences through gender bias free learning so that gender bias can be decreased, as was previously stated in the beginning of this paper.

Conclusion

Based on the results of this study, we can conclude that: (1) there is a significant difference in female and male students' perception toward mathematics even though they have slightly different score and both were categorized as moderate. (2) There is no significant difference between female and male students' perception towards science also technology and engineering. Female students have more positive perception toward science and was categorized as high while male perception was categorized as moderate. Although male have more positive than female student toward technology and engineering but both perception were categorized as high. 3) Furthermore, there is no significant difference in female and male students' motivation toward all of STEM subjects. Both have high motivation toward science also in technology and engineering but have moderate motivation toward mathematics. Female have higher motivation toward science while male have more motivation toward technology and engineering also in mathematics.

In order to improve female and male students' perceptions to Mathematics subject, male student perception to science, and to reduce gender bias on male and female students' perception toward mathematics, STEM learning should be able to provide a positive learning experience to build a positive perception. The positive learning experience is a learning that is accommodating students' characteristics,

clear, interesting, and innovative so that students can receive sufficient information about the learning. Besides, the teacher need to provide equal opportunities for female and male students in all hands-on activities, particularly in engineering and in using technological devices. Moreover, teachers and school counsellors need to support to make their female students realize that engineering and technology are prospective for female careers.

Despite providing a reduction in gender bias, STEM learning need to be able to increase students' motivation in learning mathematics. STEM learning needs to be more accessible and cohesive, especially if approaches to integrating STEM into curricula are used. Collaborative teaching

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between science, mathematics, and technology teachers needs to be considered, particularly to expose the role of Mathematics subject. Additionally, it is also essential to create comfortable, exciting, and proper learning environments for students' personal development where students can actively participate and gain successful experience.

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