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Students' interest in Science, Technology, Engineering, and Mathematics (STEM) based on parental education and gender factors

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ABSTRACT

The integration of science, technology, engineering, and mathematics (STEM) education in various fields of knowledge is needed to enhance the country's economic development. STEM education is essential in developing technology towards the Industrial Revolution 4.0 (IR4.0) era. However, in many countries, especially in Indonesia, students are less interested in STEM subjects. This study aims to identify the differences and interactions of student interest in STEM based on parental education and gender. This study uses a quantitative method involving 150 secondary school students at Simanosor Julu, Medan, Indonesia. The results of data analysis based on the mean score indicated that there are differences in students' interest in STEM-based on gender and parental education. The mean score of male students, based on parental education at the university level, is higher than female students. It is recommended that there are additional study more deeply the STEM interests of students based on (a) social-economic status, (b) rural and urban schools, (c) the relationship between the two variables, and (d) involves students with more numbers.

Keywords: STEM education, students' interest, parental education, gender, secondary school

INTRODUCTION

The needs of students facing the 4th Industrial Revolution (4.0 IR) and the 21st century require skills in

(a) creativity and innovation,
(b) critical thinking in solving problems,
(c) communication skills,
(d) ability to collaborate,
(e) information literacy,
(f) media literacy,
(g) information and communication technology (ICT),
(h) flexibility and adaptability,
(i) independence,
(j) social and cross-cultural skills,
(k) productivity and accountability, and
(l) leadership and responsibility (Siregar et al., 2020; Urban & Favlo, 2016).

Furthermore, in the 21st century, ICT advancement is one factor promoted by integrating science, technology, engineering, and mathematics (STEM) education in schools. STEM education enhances the understanding of knowledge, encourages critical thinking, and supports the realization of innovation in the teaching and learning process. The successful integration of STEM education can ensure the better development of a 21st century nation. However, past studies showed an increasing concern of a potential crisis in the industrial sector at the international level due to the lack of a skilled workforce in STEM fields. Data from the US Census Bureau and the Bureau of Labor Statistics showed that STEM-related employment grew by 8.9% from 2014 to 2024

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compared to non-STEM-related jobs at 6.4% (Noonan, 2017). Specializing in engineering and science is higher in China (23%), India (23%), and the European Union (12%) than in the US (9%) (NSB, 2016).

Many researchers noted that STEM education is essential for modern education. Nations that master STEM education will be able to become world leaders (Kanematsu & Barry, 2016). It is important to note that STEM achievements will reflect the quality of people, society, economy, and culture, which become the underlying aspects of citizens' lives (National Research Council, 2011). Improving access to STEM careers for students is very important to ensure the economic development of society and provide opportunities for every individual regardless of social background (Drazan, 2020). STEM learning is based on integrating related disciplines as an interdisciplinary approach that combines hands-on and problem-based problems to enhance children's cognitive developmental (Riera et al., 2016).

Scholars noted many positive outcomes when teachers integrate STEM into the classroom. For instance, Siregar et al. (2019) stated that the approach could cultivate optimistic attitudes and interests, improve achievement and problem-solving skills, enhance communication skills, and make education administrators aware of reformed learning techniques in the 21st century. Learning through STEM integration can also increase student engagement and interest during the classroom instructional process (Urban & Favlo, 2016). However, many students are not interested in learning STEM disciplines, especially when they further their studies at the university and choose a career (Yoder, 2017). For instance, Australia and several other industrialized countries require an extensive STEM workforce for global economic prosperity, productivity, and competitiveness. Still, the skillful workforce, which meets the job requirements does not match the demand. One of the reasons for this supply and demand issue is the decline in students' interest in choosing STEM (Perera & McIlveen, 2018). In Spain, the percentage of female students entering the university in the 2015-2016 academic year in mathematics, chemistry, or biology, accounted for 38%, 52.67%, and 61.82%, respectively, which shows the lower interest of female students in the subject of mathematics (MECD, 2017). In addition, there is a decrease in physical science admissions, with only 25.62% enrolling in the university. Concerning engineering, female students are less interested in electronics and automation, computer science, and electrical and energy, only representing 17%, 11.83%, and 17.39% (Sáinz et al., 2020). In Indonesia, a similar issue arose with a decline in student interest, especially in mathematics and science. This decrease is seen based on the mean score of students in the Program for International Student Assessment (PISA) report (Shin et al., 2018). Indonesian students are ranked 72nd places for mathematics and 70 for science subjects from 78 countries participating in the PISA. Additionally, the results of the Trends in International Mathematics and Science Study (TIMSS) show that students only reached the 44th and 47th ranks of the 49 participating countries (Mullis et al., 2016). Based on PISA and TIMSS reports, scholars noted that gender had influenced the students learning of STEM subjects.

One way to cultivate students' interest in STEM subjects is to show the relevance of STEM to students' future career goals (Liebendörfer & Schukajlow, 2017). Many researchers have identified factors such as high school experiences, parents, and teachers that may influence students to engage in learning STEM (e.g., Sahin et al., 2017, 2018). Notably, the gender factor also plays an essential drastic difference in the number of students pursuing a career in STEM. For many years, male students have been more likely to choose a career in STEM than female students (NSF, 2017). Past research showed that male students were more interested in STEM because of their self-interest in physically challenging courses (Charlesworth & Banaji, 2019; Hsieh & Yu, 2022; Siregar et al., 2022). Specifically, male students were more likely to be interested in engineering subjects than female students, who prefer the sciences in their careers. At the same time, female students are more dependent on external support than their male counterparts (Maltese & Cooper, 2017).

The research results from Franz-Odendaal et al. (2020) and Steegh et al. (2019) found that most female students from grade 7 felt tense when working on mathematics problems to get the best score compared to male students. Female students were less willing to learn about technology, such as robotics, unlike male students who had high interest and confidence when learning technology (Charlesworth & Banaji, 2019; Han, 2019; Kucuk & Sisman, 2020; Voyer et al., 2017). In most STEM subjects, especially biology, female students were less interested than male students (Biewen & Schwerter, 2022; Lloyd et al., 2018). Also, the analysis results of Holmes et al. (2017) study found that male students were more inspired by STEM careers than female students. According to Gore (2016), the comparison in students' interest in overall STEM subjects was 27% (female) and 73% (male); 47% (female) and 53% (male) in science subjects, and 9% (female) and 91% (male) for technical subjects. Male students' interest was high in STEM because they could see it as a profession and felt it suited their personality (Anaya et al., 2022). In addition, males receive many benefits while pursuing STEM subjects (Lloyd et al., 2018).

STEM interest is also influenced by external factors emanating from socializing agents such as parents, peers, and teachers, usually in the form of expectations and reinforcement of positive or negative motivations to students (Hsieh & Yu, 2022; Nite et al., 2020; Sahin et al., 2019). Students' interest in STEM is strongly inspired by parental education (Lloyd et al. (2018). Parental education is a fundamental mechanism for improving the quality of their children education. It is also the basis for shaping children's performance in learning because parents have been the first and foremost educators for their children. Lloyd et al. (2018) found that one source of inspiration and positive influence for students in making choices to take STEM subjects (such as science subjects) are parents who have a bachelor's degree; have worked in the STEM field (Holmes et al., 2017). Most children reveal that their parents are role models in determining the choice of STEM subjects (van Tuijl & van der Molen, 2016). In addition, parental support from the financial aspect and providing a proper environment are essential for students for determining STEM choices. The role of parental education is influential in guiding students to make wise choices and not feel burdened by their choices (Lloyd et al., 2018).

In addition, parental education is one of the promoters of children's involvement in their active learning, achievement, and future careers in the school environment and the community. Many teachers think that parents are the most critical factor in children's education even though teachers have professional skills in educating students. Nevertheless, the influence of parental education on student interest in STEM requires some kind of support from schools to involve parents in children's learning

Table 1. Gender and parental education categories

Variable	Value label	n
Gender	Male	82
	Female	68
Parental education	Primary school	6
	Secondary school	9
	Senior high school/vocational	80
	University	55

development. The educational factor related to parents can be seen from the efforts of parents to provide high-quality educational opportunities for their children, to produce the best academic achievement. Besides, parental education determines parenting behavior patterns and supports a child's education so that the child has good learning habits and academic performance. The academic performance of students living in cities is more influenced by their family factors than students living in villages.

Past research noted some significant other contributions of parental education. For example, Svoboda et al. (2016) argued that parents' academic qualifications can predict students' future identities in mathematics and science. Parental support also positively affects students' interest in STEM subjects. Students are more ambitious to pursue their careers in the STEM field when their parents are in STEM careers (Holmes et al., 2017). Educated parents can inspire their children by giving their bits of advice and encouragement, and by showing positive behavior directly or indirectly in STEM subjects (Šimunović et al., 2018). Past studies have shown that support from parents with higher education towards their children has a positive relationship with student achievement, school involvement, motivation, and good performance (Hoferichter & Raufelder, 2019). In addition, parents' encouragement toward STEM careers for their children can increase their confidence and interest in their abilities. The role of parents has a positive influence on the formation of student interest, and high interest has an impact on children's academic achievement (Hendrawijaya, 2022). In line with that, several studies have found that parental education has a positive role in students choosing STEM subjects and positively influences their achievement (Let's Talk Science, 2015; Perera, 2014). However, study results also suggest that parental education does not have an impact on students to determine the selection of students in STEM subjects (Šimunović et al., 2018).

Based on discussion and mixed results from the past research, the present study examined the Indonesian secondary school students' interest in STEM in regard to their parental education and gender. The guiding questions of the study are, as follows:

1. To what extent are there differences in students' interest in STEM based on parental education and gender?
2. To what extent is there an interaction effect between gender and parental education factors in students' interest in STEM?

METHODS

This study utilized a quantitative method involving 150 secondary school students (SMP) at Simanosor Julu, Medan, Indonesia, in 2019. The respondents were purposively sampled aimed at meeting the specific criteria such as

(a) to obtain similarities from the sample,

(b) the quality of research respondents in terms of interest in STEM subjects, and

(c) the experience and willingness of respondents to be involved in research (Cresswell & Plano Clark, 2011).

The selection of respondents at Simanosor Julu Junior High School was based on

(a) the school focused on thematic learning (prioritizing science),

(b) the class consisted of a similar distribution of female and males students, and

(c) the majority of students had educated parents.

Table 1 displays the demographic information of respondents in the present study.

The research instrument used to collect data was a questionnaire with a total of 44 items consisting of four constructs, science, technology, engineering, and mathematics. This instrument uses a Likert scale with five criteria, namely 1=strongly disagree (SD); 2=disagree (D); 3=neither agree nor disagree (NA/D); 4=agree (A); and 5=strongly agree (SA). The instrument was validated by two experts in mathematics and science education. The criteria for experts who were used as validators in this study were, as follows:

1. Lecturers majoring in mathematics:
    a. has taken doctoral education in the field of mathematics education and
    b. has been teaching for 20 years at IAIN Padangsidimpuan.
    c. a science teacher who has 10 years of experience teaching at Padangsidimpuan junior high school and has taken master's education in the science education program.

The instrument reliability value was based on Cronbach's alpha of 0.916. Cronbach's alpha approaching one shows greater internal consistency (Hayes & Coutts, 2020). Also, a normality test was performed that showed the Kolmogorov-Smirnov p-value=0.408 ($p>0.05$), which showed the data in this study was normally distributed. In addition, the result of Levene's test was p-value=0.510 ($p>0.05$), and the data had homogeneous variances. Since the assumptions for parametric analyses were met, the two-way ANOVA was performed to see the differences between students' interest in STEM-based on gender and parents' highest level of education.

Table 2. Cross tabulation analysis of students' interest in STEM

Gender	Parental education	Mean	Standard deviation	n
Male	Primary school	152.50	34.64	2
	Secondary school	156.83	23.55	6
	Senior high school/vocational	164.54	20.13	41
	University	171.97	17.89	33
Total		166.67	20.04	82
Female	Primary school	165.00	21.26	4
	Secondary school	172.33	16.50	3
	Senior high school/vocational	165.64	17.50	39
	University	167.00	14.00	22
Total		166.34	16.30	68

Table 3. Test of between subjects effects

Source	Type III sum of squares	df	Mean square	F	Sig.
Gender	423.38	1	423.38	1.25	0.26
Parental education	978.38	3	326.12	0.96	0.41
Gender*parental education	1,038.75	3	346.25	1.02	0.38

RESULTS AND DISCUSSION

Table 2 shows the cross tabulation analysis of mean scores on students' interest in STEM based on gender and parental education. The analysis showed the majority of mean values of students' interest in STEM increases with higher parental education for both females and males. We noted the mean students' interest in STEM for males (n=2) whose parents had the lowest education level (primary school) is 152.50 (standard deviation [STD]=34.64). It is a similar result to the mean students' interest (n=4) for females of the same category is 165.00 (STD=21.26). These mean values were the lowest students' interest in STEM based on parental education for both genders. Interestingly we found a different pattern of STEM interest for students whose parents had the highest education (university). For this category, it is shown that the mean value of students' interest in STEM for males is 171.97 (STD=17.89), which is higher than for females (mean [M]=167.00, STD=14) (Charlesworth & Banaji, 2019; Hsieh & Yu, 2022). It is remarkable to understand that parental university education does not always account for high students' interest in STEM in the case of these selected female respondents. In fact, the female students whose parental education level was secondary school showed the highest mean interest in STEM (M=172.33, STD=16.50). We strongly believed other factors such as self-efficacy and learning experiences might contribute to students' interest in STEM as noted by past researchers (Hoferichter & Raufelder, 2019; Nite et al., 2020; Sahin et al., 2019), especially in the case of female students. The integration of STEM into the classroom teaching and learning would attract students' interest in these subjects, and students who show interest in STEM over time usually have high motivation and achievement compared to less interested students.

Table 3 showed the results from the analysis of variances that was utilized to examine the differences in students' interest in STEM, based on parental education and gender. The interaction analysis showed a p-value of 0.385 (more than α=0.05) that provided evidence for failing to reject the null hypothesis "There is no interaction effect between gender and parental education in student interest STEM". Thus, the simple effect analysis of gender and parental education was further investigated to see which factors had an effect on students' interest in STEM.

The simple effects analysis showed neither gender nor parental education factors had an effect on students' interest in STEM with a p-value of .26 and 0.41, respectively. The results of this study are in line with the research of Anaya et al. (2020), Biewen and Schwerter (2022), and Hsieh and Yu (2022), who found that gender did not influence students in choosing STEM subjects. Based on the mean score, there is a slight difference in students' interest in STEM-based on gender and parental education as discussed in the first section, however, the inferential statistics analysis does not support the results. The difference in interest in STEM between male and female students is not based on gender differences because both sexes have constraints in the learning process of STEM subjects, especially mathematics (Wolfe, 2019). Future studies should consider other factors that might contribute to differences in students' interest in STEM.

Along the same line, discussion of gender is vital in STEM subjects because the involvement of everyone will create an intelligent and quality society (Charlesworth & Banaji, 2019). However, it is undeniable that there are still disparities in the interest of male students and female students in choosing STEM subjects. Male students are more interested in STEM subjects than female students (Lloyd et al., 2018). We believed there are several aspects that influence differences in student interests. First, there are differences in reasoning in the spatial aspects of students (Voyer et al., 2017). This difference is due to male and female students' nervous and mental systems. Mentally male students are more stable than female students (Voyer et al., 2017). Second, in the STEM learning process, especially in engineering subjects, the involvement of male students is more active than female students. However, female students are also active in science and mathematics subjects (Han, 2019; Steegh et al., 2019). This difference can be seen during the learning process in the classroom, such as in problem-solving discussions; male students are more active in providing ideas than female students. Female students still feel embarrassed to present their ideas and worry when the ideas they give are inaccurate. Furthermore, male students were more active in seeking information from various sources than female students (Siregar et al., 2020). However, previous research results showed no difference in the selection of STEM subjects based on gender (Anaya et al., 2020; Biewen & Schwerter, 2022; Hsieh & Yu, 2022).

In regard to parental education, previous studies also found that students' interest in STEM is not influenced by this factor (Šimunović et al., 2018; Ugwuanyi & Okeke, 2020). Parents who have a primary school, secondary school, senior high school/vocational school, and university qualificationsprovide the same support to their children, both female and male students. Parents emphasize that their children prefer STEM subjects based on the suitability of their interests without coercion in determining educational and career options (Hoferichter & Raufelder, 2019; Lloyd et al., 2018). The involvement of parents in determining a child's education genuine even though the existing literature is too often ignored by researchers, educators, and even education policymakers. In addition, some parents do not have sufficient knowledge or skills to support their children's education according to their needs (Đurišić & Bunijevac, 2017). In most developing countries, parents are very limited in understanding and do not rule out having a negative attitude towards STEM subjects (Moshfeghyeganeh & Hazari, 2021). Many factors limit parents from mastering STEM subjects. For example, parents' lack of mastery of language limits them from supporting their children. Also, parents who do not receive an education from elementary to tertiary levels will limit their ability to support students in learning meaningful STEM subjects (Ghani et al., 2020). In fact, at the same time, parents have an essential role in children learning STEM subjects (Ing, 2014). The results of Perera's (2014) research found that the education of parents (families) around children has a crucial role in determining children's education, and parental involvement in children's STEM education can be a very effective intermediary in overcoming negative impacts (Perera, 2014). Researchers have common ground that parental involvement is significant in children's education (Ghani et al., 2020; Harris & Goodall, 2008; Let's Talk Science, 2015).

Although parental education has no significant effect on students' interest in STEM, educators need to encourage students to be more interested in STEM subjects because it provides many benefits for students. The advantages of STEM learning for students are that they can be involved in

(a) workgroup problem-based learning,

(b) active involvement of parents/families in guiding students at home,

(c) helping others, and

(d) increasing student self-confidence (Kolo, 2016).

Through STEM learning, students are helped in the process of

(a) identifying the character of the problem that is important for further research,

(b) designing strategies to examine aspects of the problem,

(c) correctly interpreting the data and information collected,

(d) making reasonable conclusions, and

(e) involving various patterns of scientific discourse (Achieve, 2013).

In addition, trained students are more productive because they can apply two or more disciplines (English, 2016), and students also have high creativity (Mills, 2013). Furthermore, STEM can increase students' self-confidence, offer technical knowledge, and provide opportunities to find out about job opportunities that utilize their abilities (Edzie, 2014). Increasing students' interest in STEM subjects will have a positive effect on their daily lives and their future (Alumbaugh, 2015).

CONCLUSION

Globally, the education system is increasingly encouraging the integration of STEM in schools. STEM learning emphasizes the active involvement of students in the teaching and learning process. Hands-on and problem-based activities have become the main feature of STEM learning, so it is necessary to involve the roles of parents and schools in providing good facilities for children. Therefore, administrators, schools, and teachers need to realize that integrating STEM education should be applied in learning to cultivate students' interest from an early age. Based on the descriptive statistics of the mean scores, it was found that there are slight differences in students' interest in STEM based on gender and parental education. However, based on the results of the two-way ANOVA test, it was found that there were no significant differences in students' interest in STEM based on gender and parental education. Further studies should investigate more deeply the STEM interests of students based on

(a) social-economic status,

(b) rural and urban schools,

(c) the relationship between the two variables, and

(d) involving students with more numbers.

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