



Proceeding of International Conference on Islamic Education and Science Development (4th ICONSIDE)

Vol. 4 No. 1 (2026) 222 – 229 | E-ISSN: 3064-2310

Mataram, 10th - 11th June 2026

Exploring STEM attitudes across grades and gender among Indonesian junior high schools

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Abstract. *In the digital era, integrating technology into education has become essential, and one prominent application is within STEM education. However, despite the introduction of STEM-based learning in classrooms, it is critical to assess students' attitudes toward STEM. STEM attitudes are foundational for fostering critical thinking and measuring students' interest, confidence, and values. This quantitative study aims to assess junior high school students' STEM attitudes by gender and grade level using a survey. The survey included 15 questions divided into five dimensions. The sample consisted of 110 junior high school students from Indonesia, comprising 53 males and 57 females across grades 7, 8, and 9, with 35, 40, and 35 students in each grade, respectively. The results revealed an average STEM attitude score of 3.01, classified as moderate. Females exhibited a higher STEM attitude score (3.02) than males (2.98). A Mann-Whitney U test indicated a significant gender difference in STEM attitudes (p -value $< .001$). Regarding grade level, 7th grade had the highest average STEM attitude (3.84), followed by 9th grade (3.16) and 8th grade (3.01). The nonparametric Kruskal-Wallis test also showed a significant difference in STEM attitudes between grade levels (p -value $< .001$). These findings suggest that students' STEM attitudes are moderate, highlighting the crucial role of teachers in designing effective learning methods to foster positive attitudes toward STEM.*

Keywords: STEM Attitudes, Gender, Grades, Junior High School.

INTRODUCTION

Indonesia, with a massive population of over 200 million, should be able to develop high-quality human capital to compete with other countries. One of our efforts is through education (Fathoni, 2020). Education in the 21st century requires schools to produce students who are not only cognitively intelligent but also possess adequate skills. One approach considered capable of producing competent professionals is the Science, Technology, Engineering, and Mathematics (STEM) approach. STEM is also widely implemented in developed countries (Septiani, 2016). STEM education is implemented in various countries to prepare people to have the multidimensional skills needed in modern life (Widya et al., 2019). STEM learning is highly relevant in the era of globalization because it integrates STEM disciplines into real-life contexts, connecting schools with the world of work. Through this learning, students are expected to develop STEM literacy so they can compete and make meaningful contributions in the 21st century. Therefore, STEM learning is one solution for improving the quality of human resources while developing 21st century skills (Fathoni, 2020).

However, studies have revealed that students' attitudes toward STEM remain relatively limited. A common problem is low student interest in conventional science and mathematics instruction, even though both fields play a crucial role in student development (Kong et al., 2020). Student attitudes are a crucial foundation because they encompass cognitive, affective, and behavioral components that can influence their career interests and future academic achievement (Shojaee et al., 2019). Implementing STEM learning in schools can also help students develop positive scientific attitudes, critical thinking skills, and technological skills

necessary to face challenges in an increasingly complex and rapidly changing world (Ramlawati & Yunus, 2021).

Based on previous research, STEM learning that provides contextual problems related to learning materials can shape students' scientific attitudes (Nurmayanti & Kristayulita, 2024). Several studies have also revealed that students' attitudes towards STEM vary widely, with some influenced by gender. Research by GÖLOĞLU DEMİR et al. (2021) found a negative correlation between female students and predicted STEM attitudes. Meanwhile, Veresova & Mala (2016) found significant differences between male and female students, where females showed more positive attitudes towards school and learning. In the cognitive component, significant differences were also found between female and male students. In addition, attitudes towards school and learning are important predictors of students' academic achievement. Other studies also reported that student attitudes towards STEM implementation were in the high category, but there were significant differences by gender, with male students showing more positive attitudes than female students towards STEM implementation in learning (Kong et al., 2020). In addition to gender, differences in grade level are also thought to influence the dynamics of student attitudes, as the complexity of the material they receive in school increases (Suprpto, 2016). To date, studies on STEM attitudes in junior high schools in Indonesia that simultaneously consider both gender and grade-level variables still require more extensive empirical data to provide a picture of students' levels of learning independence and self-confidence (GÖLOĞLU DEMİR et al., 2021).

Junior high school is a crucial period for studying students' attitudes toward STEM. Adolescence is often referred to as the identity-formation phase, during which students begin to develop their views on academic subjects and career aspirations (Suprpto, 2016). Attitudes or views formed early on tend to persist over time. Therefore, it is important to recognize early on if students show low interest or hesitation in STEM fields. This way, teachers and parents can provide more engaging and appropriate learning approaches. Students who lose interest in science or mathematics by seventh or eighth grade are likely to carry this disinterest into subsequent levels of education, potentially narrowing their future career options. However, there is still little research linking this to students' scientific attitudes (Nurmayanti & Kristayulita, 2024). Therefore, the characteristics and applications of STEM, as assessed through students' perspectives or attitudes toward STEM, still require further research (Shojaee et al., 2019).

Based on these considerations, this study used a quantitative survey approach to examine STEM attitudes among junior high school students in Indonesia. The survey instrument consisted of 15 items arranged into five dimensions and was administered to 110 students, consisting of 53 males and 57 females from grades VII, VIII, and IX. This study was structured around four research questions: (1) What are the levels of STEM attitudes among junior high school students? (2) Are there differences in attitudes toward STEM between male and female students? (3) Are there differences in attitudes toward STEM based on grade level? The results of this study are expected to inform teachers and curriculum developers in designing more effective learning approaches to foster positive attitudes toward STEM from an early age.

METHOD

Research Design

This research employs a quantitative method that uses measurable variables and numerical data collected through structured instruments (Hagan, 2014). This method was chosen because it is highly efficient and effective across social, business, educational, and especially scientific fields, not least for data collection, and it also incurs low costs.

Participants

Data collection was conducted through a survey that distributed questionnaires to junior high school students. The sample consisted of 110 junior high school students from Indonesia, comprising 53 males and 57 females across grades 7, 8, and 9, with 35, 40, and 35 students in each grade, respectively, as shown in Table 1.

Table 1. The Distribution of Students in Terms of Grade and Gender

Variables	Category	Frequency	Percentage
Gender	Male	53	48.18%
	Female	57	51.82%
Grade	7	35	31.82%
	8	40	36.36%
	9	35	31.82%

Research Instruments

Because a questionnaire method was used, the questions were divided into five dimensions, each containing three questions, for a total of 15. The following are the points of each of the five dimensions:

1. Self-regulated learning: measuring students' abilities and attitudes in managing their own learning process
2. Collaborative learning environment: Cooperation and interaction between students in a group in the learning process
3. Interdisciplinary learning environment: assess how students perceive the integration of various disciplines (science, technology, engineering, and mathematics) within a single learning session.
4. Technology-based learning: students' use and attitudes towards technology in learning.
5. Hands-on activity: assessing students' attitudes towards learning activities involving direct practice

Analysis Data

Data processing was performed using IBM SPSS Statistics 27.0 to conduct descriptive statistics and normality and homogeneity tests, followed by significance tests, namely the Mann-Whitney U and Kruskal-Wallis tests.

RESULT AND DISCUSSION

To determine the appropriate statistical test for this study, the initial step was performing a normality test. The results presented in Table 2 indicate that the data were not normally distributed (Sig < 0.01; $p < 0.05$). Therefore, a non-parametric test was necessary as the next step.

Table 2. The Results of the Normality Test

STEM Attitudes	Kolmogrov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
	0.203	110	<0.01	0.882	110	<0.01

STEM Attitudes Level in Junior High School based on Gender

This section discusses the answers to the research question, "Are there significant differences in STEM attitude levels based on gender in junior high schools in Indonesia?" The mean and standard deviation of STEM attitude levels by gender in Indonesian junior high schools are presented in Table 3. The results show that female students have a higher mean of 3.03, while male students have a lower mean of 2.99, both of which are categorized as moderate. The overall mean is 3.01, also indicating a moderate level for STEM attitudes based on gender in junior high schools

Table 3. Descriptive Statistics for Participants' STEM Attitudes Level Regarding Their Gender

Gender	N	Mean	SD
Male	53	2.99	0.46
Female	57	3.03	0.45
Average		3.01	0.45

The findings of the average score for the STEM Attitudes Level based on students' gender in General are shown in Figure 1.

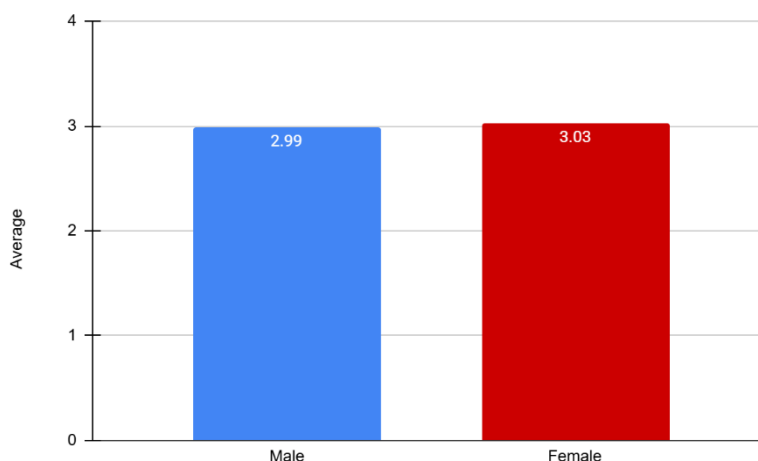


Figure 1. Average of STEM Attitudes Level based on Gender in Junior High Schools in Indonesia

The data analysis shows that, by gender, the average STEM Attitudes score for female students is higher than that for male students. These results do not necessarily indicate that Males' STEM Attitudes scores are lower. These results are also in line with the research "STEMChAT: Women as catalysts for change in STEM education" funded by Science Foundation Ireland (SFI), Ireland, which states that female students tend to have positive attitudes towards science in all aspects, while male students only have positive attitudes towards certain aspects, such as Mathematics and technology (Lane et al., 2022). The average STEM Attitudes Level scores by gender for each dimension are shown in Figure 2.

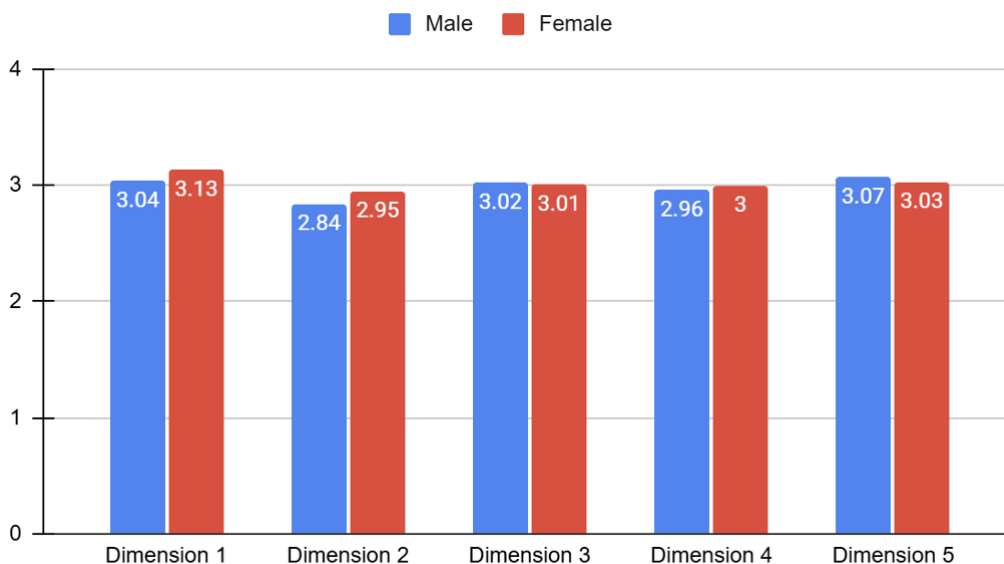


Figure 2. Average of STEM Attitudes Level for Each Dimension based on Gender in Junior High Schools in Indonesia

Based on Figure 2, the average STEM attitudes of male and female students across dimensions show a relatively balanced pattern, although female students tend to score slightly higher in most dimensions. The most prominent difference is observed in Dimension 2, where female students (2.95) obtained a higher average score than males (2.84). In contrast to the other dimensions, in dimension 5, the average STEM Attitude score for males (3.07) is higher than that for females (3.03). This shows that each gender has certain preferences regarding STEM Attitude levels. This is also in line with students at Muhammadiyah Middle School Sidoarjo, where student attitudes are most prominent in the integrated STEM dimension, followed by engineering, technology, science, and mathematics, with patterns that are not always consistent (Suprpto, 2016).

Overall, the average difference in STEM Attitudes based on gender among junior high school students in Indonesia is not very significant. However, it is worth noting that in dimension 2, namely regarding Collaborative learning environment, males and females show the lowest average in each dimension. The highest average is for female students in the first dimension, namely Self-regulated learning, while for male students in the fifth dimension, namely Hands-on activity. Because the data are not normally distributed, a further test is needed: the nonparametric Mann-Whitney U test. The results of the Mann-Whitney U test are shown in Table 4.

Table 4. The Results of the Mann-Whitney U Test for STEM Attitudes Level Based on Gender in Junior High School

Category	STEM Attitudes Level
Mann - Whitney U	281
Wilcoxon W	911
Z	-4.503
Asymp. Sig. (2-tailed)	<0.01

Based on the statistical test results in Table 4, a significance value (Sig.) of less than 0.01 was obtained. Because this value is less than 0.05, it indicates that male and female students have significantly different attitudes towards STEM.

Regarding their attitudes towards STEM (STEM Attitudes), both female and male junior high school students in Indonesia are in the moderate category, according to the descriptive data analysis results shown in Table 3. Female students have slightly higher mean scores than male students (Mean = 3.03; SD = 0.46). In Table 4, the results of the non-parametric Mann-Whitney U test show that the difference is highly statistically significant with a value of Asymp. Sig. < 0.01 ($p < 0.05$). In addition, the results indicate that female students have more positive attitudes towards STEM than male students in Indonesian junior high schools.

Another finding is that female students achieved the highest scores on the first dimension, namely Self-regulated learning, while male students had the highest scores on the fifth dimension, namely Hands on activity. Specific findings on differences in dimensional superiority between the two genders provide a more detailed picture of the psychological characteristics of junior high school students. Female students achieved the highest scores on the first dimension, namely self-regulated learning. This phenomenon may be associated with the speed of maturation of the brain's executive functions and self-regulation in adolescent girls, which generally develop earlier than in adolescent boys in the age range of 12–15 years (Pas et al., 2021). Adolescent girls tend to be more organized, have a strong intrinsic motivation to comply with academic structures, and are more diligent in managing independent study time (Perry & Smart, 2007). This is in line with research by Ladia et al. (2025), which found that female junior high school students in Indonesia exhibited higher levels of self-regulated learning than male students, indicating significant differences between the two groups. This could be influenced by several factors, including academic self-regulation skills, improved time management, and environmental and social factors.

On the other hand, male students scored highest on the fifth dimension, namely Hands-on activity. This is also in line with the research Effect of Gender on Senior Secondary Chemistry Students' Achievement in Stoichiometry Using Hands-On Activities conducted by Ajayi & Ogbeba (2017) which stated that although the difference was not too significant, male students showed a higher average achievement than female students in hands-on activity practice. The average level of STEM Attitudes in male students which tended to be higher than female students based on dimension 5, could be due to one factor, namely the stereotype of a gender role where one example in laboratory practicum, female students' tasks tended to be more in terms of taking notes 'Hermione' (working more on non-technical tasks) while male students took more active roles in using equipment (Fernandez et al., 2023). Due to the different levels of STEM Attitudes in junior high school students in Indonesia, a teacher's role in addressing differences in STEM attitudes among junior high school students is to maximize the potential of male and female students based on their STEM attitudes. Teachers must also be able to integrate appropriate learning methods so that both male and female students can learn and maximize their potential.

STEM Attitudes Level in Junior High School based on Grades

This section discusses the answers to the research question, "Are there significant differences in STEM attitude levels based on grade level in junior high schools in Indonesia?" The average and standard deviation of STEM attitude levels by gender in Indonesian junior high schools are described in Table 5. The results show that 9th-grade students had the highest average of 3.17, followed by 8th-grade students at 3.02 and 7th-grade students at 2.84. Judging from the standard deviation for each grade, we can categorize them as moderate.

Table 5. Descriptive Statistics for Participants' STEM Attitudes Level Regarding Their Grades

Grades	N	Mean	SD
7	35	2.84	0.62
8	40	3.02	0.35
9	35	3.17	0.41
Average		3.01	0.46

The average STEM Attitudes by grade showed an upward trend, with grade 7 at 2.84, grade 8 at 3.02, and grade 9 at 3.17. But overall, the average is 3.01. The increase in levels across classes indicates that higher grades are associated with higher STEM Attitudes. The findings of the average score for the STEM Attitudes Level based on students' Grades in General are shown in Figure 3.

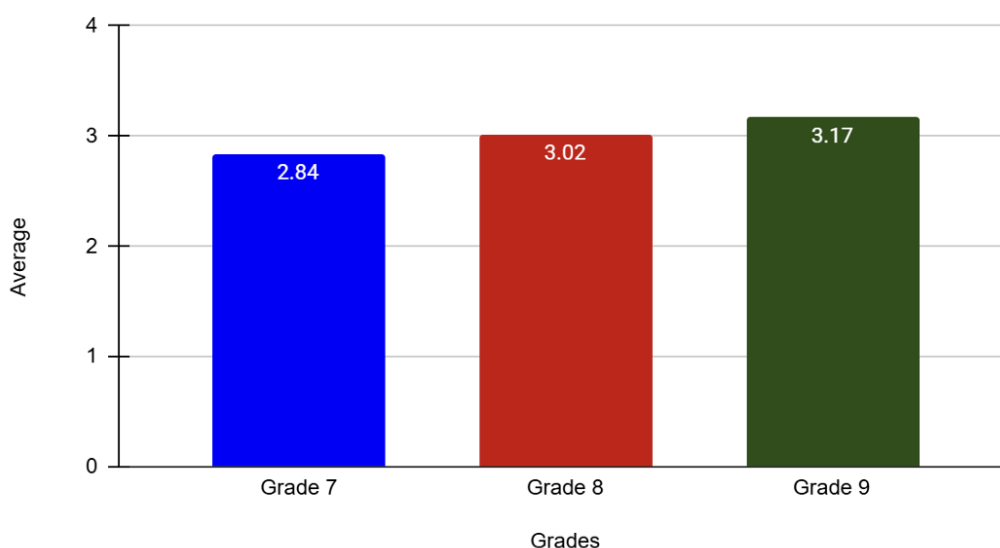


Figure 3. Average of STEM Attitudes Level in General based on Grades in Junior High Schools in Indonesia

The pattern of increasing average STEM attitudes from 7th grade (2.84) to 8th grade (3.02) to 9th grade (3.17) indicates that higher grade levels are associated with greater student learning experiences. Calculations of student learning experiences play a significant role in increasing STEM attitudes towards a more positive direction. This is in line with the argument that continuous exposure to STEM subjects contributes to the development of student attitudes. High school students were shown to outperform junior high school students in overall STEM reasoning, which is reasonable given differences in exposure to STEM and the development of understanding in the field (Mayes & Rittschof, 2021). For the level of STEM Attitudes by gender across dimensions, there is an upward trend across class levels. Data trends are shown in Figure 4.

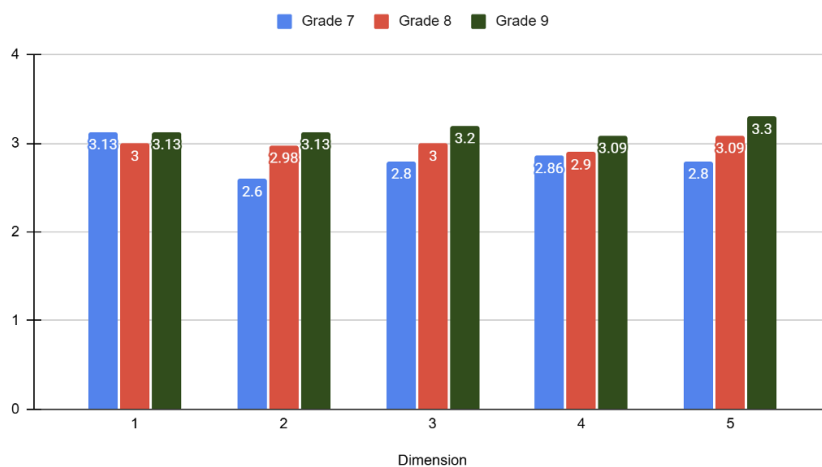


Figure 4. Average of STEM Attitudes Level for Each Dimension based on Grades in Junior High Schools in Indonesia

Based on Figure 4, it can be concluded that the higher the grade, the level of STEM Attitudes consistently increases, except in dimension 1, which shows a decline in grade 8. Other findings also show that a spike in increase was obtained by dimension 2 (mean = 2.6-3.13) and dimension 5 (mean = 2.8-3.3). This pattern indicates that the higher the grade level, the more positive students' attitudes towards STEM. This is also supported by the results of the Kruskal-Wallis Test, as shown in the following Table 6.

Table 6. The Results of the Kruskal-Wallis Test Based on Gender in Junior High School

Category	STEM Attitudes Level
Kruskal Wallis H	36.45
df	2
Asymp. Sig. (2-tailed)	<0.01

Based on the statistical test results in Table 6, the significance value (Sig.) was less than 0.01. Since this value is less than 0.05, this indicates that there is a significant difference in the level of STEM attitudes in junior high school based on grades, with increasing levels of STEM Attitudes at each grade level.

CONCLUSION

This study discussed attitudes of junior high school students in Indonesia toward STEM (Science, Technology, Engineering, and Mathematics) by gender and grade level. The results indicate that STEM attitudes in junior high school are moderate and still have potential for development. Based on gender, the average STEM attitude level for girls is higher (mean = 3.01) than for boys (mean = 2.99). However, both males and females have their own strengths. Females have advantages in self-regulated learning, while males have advantages in hands-on activity. By grade level, STEM attitudes increase, which is understandable because higher grades are associated with greater self-confidence and learning experience. The highest spikes are in dimensions 2 (collaborative learning) and 5 (hands-on activities), which can serve as opportunities to improve STEM attitudes across other dimensions.

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