Indonesian students' STEM career motivation: a study focused on gender and academic level

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Abstract. The STEM field faces challenges related to uncertainties about the number and composition of skilled workforce. Measuring STEM career motivation (STEM-CM) of students at an early grade is crucial to improve the quality of science learning and to engage more students in STEM fields. This study focuses on the gender and academic level issues related to STEM career motivation. A total of 1583 elementary and middle school students participated in investigating two research questions: (1) Do gender and academic level impact students' STEM career motivation? (2) How to classify students based on their STEM-CM? This study revealed that gender was not significantly related to STEM-CM. Nonetheless, academic level impacted significantly with STEM-CM where students' motivation declined from elementary to middle school. Furthermore, the clustering method elicited five groups of students for consideration in designing STEM teaching activities. The influenced factors of students' motivation for STEM careers were discussed. Finally, customized learning to improve student engagement in STEM was recommended.

1. Introduction

Global competition in many sectors, particularly with rapid advances in science and technology, has been a challenge for all nations in the 21st century. Many countries have emphasized the integration of science, technology, engineering, and mathematics (STEM) to solve real-world problems [1-2]. In addition, the data shows that STEM fields' job vacancies have increased significantly and outpaced those of other jobs [3]. Thus, STEM has been suggested to be one of the most promising areas for future careers. Occupations in STEM-related careers are the fastest growing and best paid, and they have enormous potential for job growth. It has been predicted that 75% of all jobs will require STEM skills over the next decade.

Most countries have made significant efforts and investments in STEM education, which has become a trend in current education [4]. Nonetheless, it was reported that the number and the composition of a trained workforce had not met the demand [1]. Although STEM education is believed to be a way of improving, engaging, and inspiring science learning [5], students' enthusiasm for STEM pursuits is inadequate in most countries. Besides, there has been a long-held stereotype that science is challenging to learn, especially STEM, because it required higher-order thinking skills. Therefore, the issue for every nation is not only about preparing students with STEM knowledge and skills. Still, it should concern the students' learning experience that could encourage their motivation toward STEM fields.

Improving students' motivation in STEM has been a crucial issue in science education because motivation refers to what directs and sustains people's actions and beliefs and encourages what they do.
Motivation psychologically describes what one does, the behavioral choice, the persistence of the behavior, and the cognition of an emotional reaction accompanying the action [6]. Previous research recognized that career motivation is an external factor that encourages students to persist in science [8]. The social cognitive career theory (SCCT) interrelates the academic experience, career interests, and future expectations with how the educational and career choice was made and how academic and career success was obtained [9]. Career motivation influences students' engagement in science including students' grade motivation, self-determination, self-efficacy, and track choice [10]. Thus, students' motivation to pursue a career in the STEM field needs to be emphasized in science learning theory and practice.

The early interest in STEM is a critical factor in persistence. The researchers believe that middle school is the pivotal stage in developing students' interest and preparing them for future skilled STEM work [11,12]. Remarkably, STEM education should be grounded in school culture [2] from the lower academic levels. According to the presented rationales, this study explores students' career motivation in STEM across elementary and middle school levels. Besides, the masculinity stereotyping in society become one of the essential issues confronted by this field [13]. Research reveals that students commonly have different experiences in science based on gender [14,15], and few studies interrelate gender and academic transition with motivation [16]. Therefore, this study explores the impact of gender and academic level on students' career motivation in STEM. Two research questions have arisen in this study (1) Do gender and academic level impact students' STEM career motivation? (2) How to classify students based on their motivation for STEM careers?

2. Methods

2.1. Participant
A total of 1583 Indonesian students from public and private schools responded to the STEM-CS instrument. Data from 385 elementary and 1198 middle school students were collected to address the research questions. Specifically, the elementary students from 4th to 6th grade (9-12 years old) consisted of 193 (50.1%) males, 186 (48.3%) females. Meanwhile, middle school students from 7th to 9th grade (12-15 years old) consisted of 597 (49.8%) males and 590 (49.2%) females.

2.2. Instrument
STEM-CM was developed by Shin et al. [10], initially to measure high school students' career motivation in STEM. This instrument followed the Social Cognitive Career Theory (SCCT) [9], which focused on self-efficacy belief, academic performance, interest, and choice. The instrument has five ordinal categories (1 for strongly disagree – 5 for strongly agree) and a multidimensional framework. It consists of 32 items divided into seven dimensions: educational experience, career value, academic self-efficacy, career self-efficacy, career interest, parent's support, and career motivation.

2.3. Data Analysis
The impact of gender and academic level on the students' STEM career motivation was identified by performing two-way ANOVA. Additionally, the clustering analysis based on students' abilities was conducted to have statistical evidence of the students' classification. The evidence also supports to design effective STEM instruction. The analysis was conducted by employing the 'mclust' package provided by R software. The higher the BIC value, the better the accuracy in determining the number of clusters [17]. After the number of groups has been decided, every student was enrolled in a group. The mean of students' motivation in seven dimensions (person measure in the logit unit) was analyzed using IBM Statistics. Therefore, the characteristics of each group can be examined.
3. Result and Discussion

3.1 The impact of gender and academic level on students’ motivation in STEM careers

The result of the impact of gender and the academic level was presented in Table 1. Students’ motivation in the seven dimensions is not impacted significantly by gender ($p > 0.05$). However, it is affected substantially by the academic level ($p < 0.05$). The interaction between gender and academic level contributes to a significant effect on students’ motivation in the dimensions of career self-efficacy and career motivation.

| Dimension                  | Gender (G) | Academic Level (AL) | G x AL |
|----------------------------|------------|---------------------|--------|
|                            | $F$        | $p$-value           | $\eta^2$ | $F$   | $p$-value | $\eta^2$ | $F$   | $p$-value | $\eta^2$ |
| Educational experience     | 3.570      | 0.059               | 0.002   | 3.570 | 0.000     | 0.035   | 3.595 | 0.058     | 0.002   |
| Career value               | 1.847      | 0.174               | 0.001   | 1.847 | 0.000     | 0.013   | 0.609 | 0.435     | 0.000   |
| Academic self-efficacy     | 2.590      | 0.108               | 0.002   | 2.590 | 0.000     | 0.033   | 0.229 | 0.632     | 0.000   |
| Career self-efficacy       | 0.158      | 0.691               | 0.000   | 0.158 | 0.000     | 0.029   | 5.651 | 0.018     | 0.004   |
| Career interest            | 0.545      | 0.460               | 0.000   | 0.545 | 0.000     | 0.013   | 0.245 | 0.621     | 0.000   |
| Parent support             | 0.017      | 0.895               | 0.000   | 0.017 | 0.000     | 0.009   | 1.142 | 0.285     | 0.001   |
| Career motivation          | 0.302      | 0.582               | 0.000   | 0.302 | 0.000     | 0.029   | 5.205 | 0.023     | 0.003   |

There is significant difference of mean score between elementary and middle school students. The significant impact of academic level exists in all STEM-CM dimensions: educational experience ($F = 3.570, p = 0.000, \eta^2 = 0.035$), career value ($F = 1.847, p = 0.000, \eta^2 = 0.013$), academic self-efficacy ($F = 2.590, p = 0.000, \eta^2 = 0.033$), career self-efficacy ($F = 0.158, p = 0.000, \eta^2 = 0.029$), career interest ($F = 0.545, p = 0.000, \eta^2 = 0.013$), parent support ($F = 0.017, p = 0.000, \eta^2 = 0.009$), and career motivation ($F = 0.302, p = 0.000, \eta^2 = 0.29$). Figure 1 depicts the declination graph from elementary to middle school in all dimensions, which indicates that elementary school students have higher STEM career motivation in all dimensions.

Furthermore, there is the significant of the interaction between gender and academic level to students’ career self-efficacy ($F = 5.651, p = 0.018, \eta^2 = 0.004$). Figure 1 shows that at the elementary level, males have higher career self-efficacy. In contrast, females have higher career self-efficacy in middle school. The interaction between gender and academic level also give impact on students’ career motivation ($F = 5.205, p = 0.023, \eta^2 = 0.003$). Figure 1 depicts that at the elementary level, males have higher career motivation. Meanwhile, females have higher career motivation at the middle school level.
Figure 1. The interaction of gender and academic level on students' motivation to pursue STEM careers

Firstly, research conducted reported that students experienced disappointed feelings in their secondary science classroom studies. The expectation concerning science class in secondary school does not meet up to expectations [18]. They lose the close relationship between teachers and students they experienced in primary school. The social cognitive career theory states that the learning experience would influence their self-efficacy and outcome expectations toward science. Further, the expectation influences the interest and choice goals regarding STEM fields. Motivational beliefs influence content knowledge and outcome expectation, consequently impacting the students' interest in choosing particular career goals [4].

Secondly, the complexity of science learning materials in middle school can be difficult for many students, affecting their science performance. The research explained that the failure and mastery experiences in pursuing goals might provide feedback, impacting both interest and motivation [9]. Positive performance can confirm students' self-efficacy and expectations and strengthen their motivation. However, negative results make students revise their self-efficacy and expectation, which
affects their interest, motivation, and career goal choice. The lower engagement between students and teachers and science learning difficulties associated with worse results causes students' motivation to decline during the transition from elementary to middle school. Finally, this result suggests that educational stakeholders need to be concerned about effective science teaching methods and middle school learning to provide a better science learning experience that exceeds students' expectations.

Furthermore, the interaction between gender and the academic level was noted as a significant result in career self-efficacy and career motivation. Male students in elementary school had significantly higher career self-efficacy. However, female students outperformed them at the middle school level. The same result shows that males in elementary school also have substantially higher career motivation in STEM, but females even exceeded them in middle school. Based on social cognitive career theory, self-efficacy has a positive correlation with interest. There is gender bias embedded in the culture, which shapes boys' and girls' behavior. The culture maintains the traditional view of what is appropriate for girls and boys, and it indirectly conveys the idea that science is more suitable for boys. Elementary students bring this cultural value to the school, influencing positive male attitudes toward science in elementary school [15]. The masculinity stereotyping occurs in elementary students. Besides, there are a few female gender roles to motivate female students to pursue science.

Despite the decline of students' motivation across academic levels, the female students outperformed males significantly in middle school in career self-efficacy and career motivation in STEM. Although stereotyping still exists in society, female Indonesian students' performance in science classrooms shows better results than males, especially in the more complex material in middle school. The PISA 2018, which assessed 15-year-old students' proficiency in reading, mathematics, and science, reported that Indonesian female students outperformed males in science by seven score points [19]. The accomplishment of the learning experience in science can increase female students' self-efficacy and motivation [9]. Therefore, it encourages Indonesian female students to pursue careers in STEM.

3.2 The impact of gender and academic level on students’ motivation in STEM careers

Students' responses regarding motivation in pursuing a STEM career were further analyzed to classify students into specific groups. The possibility of a 1-10 group was input. The result shows the highest BIC (value = -37254.23) considered 5 group classification with the VEE model (an ellipsoidal distribution with uniform shape and orientation and variable volume) [17]. Figure 2 visualizes the five groups with Pearson measure value comparisons of each dimension.

![Figure 2. Students' classification based on STEM-CM](image-url)
Figure 2 illustrates that students' motivation toward STEM careers inclines from the first to the fourth group. The fifth group is exceptional since the person measure across dimensions is significantly different. The number of students in each group based on gender and academic level is presented in Table 2. The first group has lower STEM career motivation. This group consists of 31 students with low academic ($M = 0.601, SD = 0.194$) and career self-efficacy ($M = 0.618, SD = 0.100$). The second group shows students with slightly higher motivation than the first group. It has almost the same score as the dimensions. The lowest value is in educational experience ($M = 1.633, SD = 1.429$). This group dominated the students' representation and consisted of 753 students. The third group consists of students with slightly higher STEM career motivation than the first and second groups. This group's lowest score is in the career interest dimension ($M = 2.695, SD = 2.422$). This group was dominated by a large number of students (652 students). The fourth group consists of 72 students with high parent support ($M = 3.432, SD = 0.216$), but were low in academic self-efficacy ($M = 2.787, SD = 0.639$). In addition, the fifth group consists of students with high academic self-efficacy ($M = 3.599, SD = 1.328$), but they have the lowest parental support ($M = 0.231, SD = 1.239$) across the different groups. This group consists of 101 students, who are mostly female and from the middle school level. The distribution of each group by gender and track can be seen in Table 2.

### Table 2. The student's group distribution based on gender and academic level

| Group | Gender | Academic Level |
|-------|--------|----------------|
|       | Male   | Female | Elementary School | Male   | Female | Middle School |
| 1     | 14     | 17     | 2.12 | 4 | 1.04 | 27 | 2.25 |
| 2     | 356    | 393    | 48.94 | 131 | 34.03 | 622 | 51.9 |
| 3     | 327    | 287    | 35.74 | 216 | 56.10 | 409 | 34.1 |
| 4     | 32     | 40     | 4.98 | 13 | 3.38 | 60 | 5.01 |
| 5     | 34     | 66     | 8.22 | 21 | 5.45 | 80 | 6.68 |
| Total | 763    | 803    | 100 | 385 | 100 | 1198 | 100 |

The group characteristic based on demographic variables was analyzed by Chi-squared test. The student motivation in pursuing careers in STEM is related to gender ($\chi^2 = 14.841, p = 0.005$) and academic level ($\chi^2 = 59.773, p = 0.001$).

The group classification procedure using the mclust package can give new insights into how academic stakeholders construct students' groups. This method provides statistical data regarding specific information on each group. Thus, the teacher can effectively design science learning methods by customizing materials for the classroom students. A festive program positively impacts students to engage more in science learning and increases motivation [4]. Concerning each group's specific characteristics, the first group consists of 14 male and 17 female students who have low academic and career self-efficacy in a STEM career. They represent a small percentage of students, and most of these students are from middle school grades. The previous discussion mentioned that students' self-efficacy is lower at higher academic levels due to unfulfilled expectations in science learning. Previous researchers [20] noted the four primary sources of self-efficacy include mastery experiences, vicarious experiences, social persuasion, and physiological states. It was also stated that student accomplishment and vicarious learning could enhance students’ self-efficacy [21]. Students are expected to have higher academic self-efficacy if they experience it. Therefore, science activity with gradually increasing difficulty level is suggested to be conducted in the classroom. This aims to make students master the material more easily and enjoy their performance in science class. Teachers can also design fun science activities such as game-based learning or technology to encourage enjoyable learning, which is familiar these days. Game-based learning on STEM reportedly increased students' knowledge and self-efficacy.
On the other hand, to improve the students' career self-efficacy, a teacher can design vicarious learning exercises. Additionally, teachers can motivate students by showing and telling stories of successful people in STEM careers and provide them with specific expectations of a future career in the STEM field.

The second group has a low educational experience. Students did not have enough information about the opportunities and types of work-related to STEM. This group consists of 753 students, which is the majority of the participants. They need to be educated regarding the various opportunities in a STEM career from books, science activities, or teachers. Regarding science activities, teachers can design project-based learning, laboratory activities, and outside school activities. Also, teachers should be provided with appropriate professional development for acquiring STEM literacy. The third group has a low career interest. This group is also a dominant one with a large number of participants and consists of 652 students. Students' participation in out-of-school time (OST) science activities plays a significant role in STEM career interest [24]. STEM activity with hands-on project-based learning also can increase students' interest in STEM and STEM careers [25]. The fourth group is the group where students' motivation has been higher than the others. The same treatment to improve academic self-efficacy can be applied. On the other hand, the fifth group has low parental support. The parenting program encourages good communication between parents and students, students and teachers, and parents and schools regarding students' future career needs.

4. Conclusion
Preparing students for the future STEM workforce has become a challenge for all nations. Specifically, motivation has been an essential aspect because it helps students persist with complex learning materials in STEM for an extended period. This study reveals the significant descending trend of Indonesian students' career motivation on STEM across academic levels. Furthermore, it was provided the clustering method for designing the customized learning. This study also showed the importance of culture, which family and society constructed. It indirectly affected how students build their gender identity and perceive what they should behave and not. Consequently, it also impacts their motivation in STEM careers. It is recommended for teachers and educational stakeholders to expose STEM experiences early and keep assessing when they continue to the higher academic level. Furthermore, gender equity in science learning should be promoted and concerned by educational stakeholders and society.

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