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<https://doi.org/10.1057/s41599-025-04446-2>

OPEN

Factors influencing student interest in STEM careers: motivational, cognitive, and socioeconomic status

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There is a disparity between the number of graduates and the demand for professionals in science, technology, engineering, and mathematics (STEM)-related fields globally. This gap underscores the importance of understanding and addressing the factors that drive student interest in the STEM career. Consequently, the education sector around the world is increasingly focused on identifying and improving these influencing factors to better align educational outcomes with the needs of the STEM industry. Thus, this study examined the cognitive (mathematics knowledge, science knowledge, and academic achievement), motivational (self-efficacy and outcome expectation), and socioeconomic status (parents' education and family income) factors involved in predicting student interest in pursuing STEM careers. The data were conducted from tests, questionnaires, and documents from grade 10 and 11 students ($n = 738$) in Indonesia. In addition, two theoretical models (i.e., Models 1 and 2) were developed and were tested using structural equation modeling. The results showed that both models met the required standards for good fit, but Model 2 fit the data better overall, while Model 1 was only slightly below the ideal range for one measure (RMSEA). We found that motivational and cognitive factors were crucial predictors in shaping student interest in general STEM and STEM discipline-specific fields. A strong indirect effect was found in the relationship between self-efficacy and career interest through the outcome expectation factor, and the indirect effect of mathematics and science knowledge on interest in STEM careers through academic achievement is an important concern. Similar and different factors are discussed in terms of student interest in general STEM-related fields and STEM discipline-specific careers.

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Introduction

Innovations in the 21st century led to changes in the technology-orientated market which requires people to possess skills in information processes, problem-solving in technology, and knowledge of interdisciplinary issues, especially in fields involving science, technology, engineering, and mathematics (STEM) (Sahin et al. 2018; Tyler-wood et al. 2018; Yerdelen et al. 2016). Thus, scientists are needed to deal with the challenge of the technology-orientated market of the 21st century (Kier et al. 2014; Tyler-wood et al. 2018).

The increased need for STEM professionals has motivated the education sector to invest in STEM-related education by creating partnerships with STEM companies, thereby engaging students in a wide range of STEM activities, and providing scholarship programs in STEM fields (Bahar and Adiguzel 2016; Kier et al. 2014). However, there is a considerably disparity between the number of graduates in the STEM area and job vacancies; thus, the number of students studying in STEM areas must be increased (Kier et al. 2014; Mau and Li 2018; Sahin and Waxman 2021). These situations can be observed in the United States of America, Malaysia, Turkey, and Indonesia (Bahar and Adiguzel 2016; Kier et al. 2014; Mohtar et al. 2019; Turner et al. 2019; Yerdelen et al. 2016). Evidence clearly suggests that capable students do not want to choose careers in the STEM fields (Yerdelen et al. 2016). Thus, investigating the motivating factors driving students to become interested in STEM careers is a crucial starting point (Mau and Li 2018). This is expected to enhance our comprehension of how students grasp STEM content and offer direction in terms of designing interventions and education programs for teachers (Halim et al. 2018).

Previous studies have investigated factors that affect STEM career interest using social cognitive career theory (SCCT), and most studies have agreed that self-efficacy and outcome expectation, that categorized as motivational factors, strongly influence interest in continuing a STEM career (Kier et al. 2014; Sahin et al. 2018; Sahin and Waxman 2021). Students with high self-efficacy tend to impact their outcome expectation, and they will be interested in a STEM career (Mohtar et al. 2019; Sahin et al. 2018). In addition, various other factors, e.g., socioeconomic status (SES) factors (parents' education, income, etc.), environmental factors (parents and teacher support), and cognitive factors (grade point average (GPA), mathematics and science achievement, and problem-solving) are predicted to directly influence student career interests (Balta et al. 2023; Halim et al. 2018; Japashov et al. 2022; Ketenci et al. 2020; Sahin et al. 2018; Yerdelen et al. 2016). These variables have a direct impact on student interest in STEM careers. Furthermore, indirect factors have also been identified, including learning experience through self-efficacy, SES (parents' education through family income), grade and gender through self-efficacy, social influence through self-efficacy, and STEM gender stereotype through self-efficacy (Fong and Kremer 2020; Kier et al. 2014; Koyunlu Ünlü and Dökme 2020; Luo et al. 2021; Mohtar et al. 2019; Turner et al. 2019). SES and domain-specific knowledge are crucial factors; however, these factors are rarely investigated in the relevant area due to the challenging assessment processes.

Previous studies have been conducted within a diverse multicultural background; however, a common limitation observed in these studies is an emphasis on only a single factor or a narrow focus on a specific aspect in a small sample size (Bahar and Adiguzel 2016; Ketenci et al. 2020; Yerdelen et al. 2016). Furthermore, these previous studies have been conducted in Western countries, Central and Southwestern Asia. It is important to acknowledge the absence of comprehensive studies on the factors influencing STEM career interest in Southeast Asia and developing countries, including Malaysia, Indonesia, Kazakhstan and

Cambodia, where the limited research— particularly in Indonesia — often suffers from small sample sizes, simplistic analyses, and narrow focus on a few variables (Alam et al. 2021; Almukhambetova and Kuzhabekova 2020; Azura et al. 2023; Balta et al. 2023; Halim et al. 2018, 2023; Mohtar et al. 2019; Nakamura 2015; Nguyen 2021; Razali 2021; Siregar and Rosli 2021; Sovansophal and Shimizu 2019). These studies also show that self-efficacy, outcome expectation, and students' achievement in science, mathematics, and 21st century skills directly impact STEM career interest, with self-efficacy also influencing interest indirectly (Almukhambetova and Kuzhabekova 2020; Azura et al. 2023; Balta et al. 2023; Halim et al. 2018, 2023; Mohtar et al. 2019; Nakamura 2015; Nguyen 2021; Razali 2021; Sovansophal and Shimizu 2019). Additionally, parents' education and occupations strongly affect Asian students' STEM career interests (Nguyen 2021; Siregar and Rosli 2021).

According to the previous studies, it is showed that the characteristics of students from these regions differ and cause different results; for example, Western countries, Central, and Southwestern Asians have more Western-like, individualistic values, whereas Southeast Asians have more collectivistic cultural values. Furthermore, due to these differences in the characteristics of students, there are varying impacts on factors influencing students' interest in STEM career. For example, in Western and Western-like cultures, self-motivation and self-efficacy are the most significant factors affecting students' decisions regarding STEM career interest, as these cultures emphasize personal goals and achievements (Bahar and Adiguzel 2016; Ketenci et al. 2020; Yerdelen et al. 2016). Conversely, in collectivist cultures such as those in Southeast Asia, SES, including parents' educations, has a big potential to be a crucial factor for students to decide their interest in STEM career due to the cultural emphasize collective well-being over personal achievement (Ketenci et al. 2020; Yerdelen et al. 2016).

Given these cultural distinctions and the gaps in existing research, it is important to conduct research in Southeast Asia, particularly in Indonesia. Indonesia is relevant research site due to its status as one of the largest and most populous countries in Southeast Asia and its high demand for STEM professionals, providing a significant and relevant context for studying educational factors in the region. Indonesia's educational system and societal conditions also reflect many aspects common to other Southeast Asian countries, making it a valuable case study to understand broader regional trends. Furthermore, Indonesia has transitioned to a digital economy projected to reach USD 146 billion by 2025, which is expected to increase demand more for STEM graduates, as technology-related occupation grew from 445,068 to 602,022 jobs between 2016 and 2020 (Gayatri et al. 2023). Since 2013, Indonesia has introduced policies to integrate STEM into mathematics and science subjects through problem-solving (Government Regulation Number 24 Year of 2016 Attachment 15, 1 (2016); Government Regulation Number 24 Year of 2016 Attachment 6, 1 (2016)). In the new 2023 curriculum, STEM-based projects have become a requirement for middle and high school students. Additionally, the Indonesian government has collaborated with international agencies to strengthen STEM education. For example, partnerships with the United States Agency for International Development aim to develop STEM-based learning models (Nugroho et al. 2019), while programs like Honeywell's partnership with Indonesian university (Honeywell 2018), and a project between Columbia University and Bogor Agricultural Institute seek to improve STEM teaching in Indonesian high schools (Teachers College - Columbia University 2013). Despite these efforts, data from the National Development Planning Agency in 2022 indicated that Indonesia

produced only eight STEM-related graduates per 10,000 people (Bappenas 2023).

Motivating student STEM career interest at lower high school will affect career decisions when students complete their high school education (Mau and Li 2018); however, studies targeting the high school level are relatively scarce compared to those focused on postsecondary students (Sahin et al. 2018). Thus, there is an urgent need to conduct research that explores STEM career interest among high school students.

The need for a comprehensive model and an empirical study of the factors influencing STEM career interest motivated us to conduct a study focusing on Indonesian high school students. This present study attempts to analyze theoretical models of the factors that influence STEM career interest and every STEM discipline-specific career interest. In this study, we examined motivational factors (i.e., self-efficacy and outcome expectation), cognitive factors (i.e., mathematics knowledge, science knowledge, and academic achievement), and SES factors (education level of mother and father, and family income). These factors are directly and/or indirectly correlated; thus, our focus turned to the following question: “To what extent do the self-efficacy, outcome expectation, mathematics knowledge, science knowledge, academic achievement, parents’ education, and family income variables interact to predict STEM career interest and STEM discipline-specific career interest in students?”

According to previous studies and literatures, our study focuses on cognitive factors, motivational factors, and SES due to their significant association and practical relevance in understanding STEM career interest. Having a focus on these categories, we aim to provide a detailed analysis that inform targeted educational interventions. Furthermore, it is necessary to conduct a study on both the general STEM career interest and each of the discipline-specific career interest, as each STEM discipline has unique characteristics, educational pathways, and career opportunities that can be predicted by different factors. By examining both generally and specifically, we can identify discipline-specific influence, develop a targeted strategy, and enhance overall STEM engagement (e.g., help educators and policymakers design comprehensive programs that encourage overall STEM engagement while also boosting interest in underrepresented discipline).

Theoretical background

Self-efficacy and outcome expectations in STEM career interest. Self-efficacy and outcome expectations are predicted as factors that influence STEM career interest according to SCCT (Lent et al. 1994). SCCT is a model to predict interest and career choice by integrating individual, behavioral, and environmental factors. The individual aspect of SCCT is focused on self-efficacy, outcome expectation, goals and interest. Self-efficacy is related to beliefs in one’s capability to accomplish a task, and outcome expectation is related to beliefs regarding the results or consequences of specific actions. In addition, self-efficacy and outcome expectation tend to promote interest, and these three variables jointly promote choice goal. Outcome expectation is also influenced by self-efficacy because, if individuals believe that they can complete the task, they are likely to understand and accept the positive outcome of engaging with the task.

Several studies have investigated models related to self-efficacy and outcome expectation as direct and indirect factors that influence STEM career interest. Direct influencing factors are variables that have immediate and observable effect on the STEM career interest without being mediated by other variables. Indirect influencing factors affect the STEM career interest through one or more mediating variable. For example, Sahin et al. (2018) evaluated a model that considers contextual, personal, and self-

efficacy factors, and they concluded that self-efficacy directly influences interest in STEM careers. Another study by Turner et al. (2019) demonstrated that self-efficacy and outcome expectation predict STEM career interest, and self-efficacy also indirectly predicts STEM career interest through outcome expectation. Luo et al. (2021) used a similar model based on SCCT to investigate a set of effects, both direct and indirect: (1) the direct effect of outcome expectation and self-efficacy on STEM career interest; (2) the indirect effect of self-efficacy on STEM career interest with outcome expectation as a mediator; and (3) the indirect effect of STEM gender stereotype on STEM career interest through self-efficacy and outcome expectation. The results revealed that self-efficacy is the strongest direct predictor ($\beta = 0.38$), which was followed by outcome expectation ($\beta = 0.30$). They also found that self-efficacy significantly predicts STEM career interest through outcome expectation. Finally, Garriott et al. (2014) concluded that self-efficacy significantly predicts STEM career interest ($\beta = 0.75$) and indirectly predicts STEM career interest through outcome expectation, and that outcome expectation does not significantly predict STEM career interest. The most recent studies have concluded that self-efficacy, along with environmental factor, behavioral factor, gender, and nationality, predicts student interest in STEM career (Msambwa et al. 2024; Sellami et al. 2023). In addition, motivational disposition particularly utility values, and self-efficacy affected student interest in STEM career (Ozulku and Kloser 2024).

Several studies have been conducted in collectivist culture in Southeast Asia and other developing countries examining self-efficacy and outcome expectations as predictors of STEM career interest. Studies among Malaysian and international Asian students have shown that self-efficacy strongly predicts general STEM, physics, and science career interest (Halim et al. 2018, 2023; Mohtar et al. 2019; Nguyen 2021). However, these studies primarily focused on a single motivational variable in predicting STEM career interest. Another study, which considered additional variables in predicting Malaysian STEM career interest, found that (1) self-efficacy ($\beta = 0.38$, $p < 0.001$) and outcome expectations ($\beta = 0.54$, $p < 0.001$) predict STEM career interest, and (2) self-efficacy also predicts STEM career interest indirectly through outcome expectations (Alam et al. 2021). Studies from Indonesia reported that self-efficacy ($\beta = 0.08$, $p < 0.001$ and $\beta = 0.12$, $p < 0.001$), outcome expectations ($\beta = 0.26$, $p < 0.001$ and $\beta = 0.32$, $p < 0.001$), interest, and economic, social, and cultural status significantly influence Indonesian students’ pursuit of STEM careers (Azura et al. 2023; Nakamura 2015). However, Azura et al. (2023) noted a limitation due to a small sample size. A study involving a large sample of Cambodian students found that factors influencing students’ interest in science and engineering fields included science and mathematics achievement and self-efficacy (Sovan-sophal and Shimizu 2019). Another study that interviewed Kazakhstani students concluded that self-efficacy and students’ disciplinary knowledge in STEM influenced their decision to pursue STEM careers (Almukhambetova and Kuzhabekova 2020).

Therefore, according to these previous studies, we hypothesize that (1) self-efficacy and outcome expectation directly predict STEM career interest, and (2) outcome expectation is the moderator of the relationship between self-efficacy and STEM career interest.

Science knowledge, mathematics knowledge, and academic achievement in STEM career interest. The SCCT holds particular relevance to the present study. This theory states that the mastery of skills and knowledge likely exerts the strongest

influence on self-efficacy (Lent et al. 1994). Thus, personal attainment of the necessary skills, knowledge, and expertise for a given profession influences an individual's sense of efficacy in performing related tasks (Adedokun et al. 2013; Lent et al. 1994). Students who perceive that they grasped mathematics knowledge and skills are more likely to have a high level of self-efficacy, and those with high grades in science and mathematics are more interested in selecting STEM careers, and vice versa (Balta et al. 2023; Fong and Kremer 2020). In addition, mastery of skills and knowledge also directly influence interest and performance.

The SCCT was used by Adedokun et al. (2013) to examine a model of factors that influence interest in research careers. Research skills and knowledge are hypothesized to directly and indirectly influence interest in research careers through self-efficacy. The results demonstrated that the indirect effect of research skills and knowledge is stronger ($\beta = 0.34$) than the direct effect ($\beta = 0.22$). In addition, Fong and Kremer (2020) evaluated a model of factors influencing mathematics outcome (GPA, college attendance, and STEM interest). They found that mathematics self-efficacy and mathematics ability directly influence mathematics outcomes (including GPA and STEM interest). Mathematics achievement has also been identified as a mediating factor in the association between gender and STEM career interest (Wang et al. 2015). In addition, mathematics achievement directly influences STEM career interest ($\beta = 0.78$). The most recent study has concluded that both academic achievement and motivation significantly impact students' interest in STEM career (Myint and Robnett 2024).

Several studies in collectivist culture in Southeast Asia and developing countries have indicated that disciplinary knowledge predicts students' interest in STEM careers. Studies of Kazakhstani students concluded that mastery of physics influences their choice of a STEM career (Balta et al. 2023), and interviews with students revealed that STEM knowledge is a significant factor in their STEM career decisions (Almukhambetova and Kuzhabekova 2020). Razali (2021) conducted a study on Malaysian students, finding that 21st century skills impact students' interest in STEM careers. Similarly, a study on Cambodian students reported that those who excel in science and mathematics are more likely to choose science and engineering fields ($\beta = 0.83, p < 0.001$) (Sovansophal and Shimizu 2019). However, these studies are limited by small sample sizes and a narrow focus on only a few variables.

Thus, according to these previous studies, we hypothesize that (1) mathematics, science knowledge, and academic achievement directly predict STEM career interest, (2) mathematics and science knowledge predict STEM career interest through academic achievement, and (3) mathematics knowledge and science knowledge predict STEM career interest through self-efficacy.

SES in STEM career interest. The SCCT states that the background factor influences STEM career interest indirectly through the motivational factor (Lent et al. 1994). The background factor includes SES (parents' education and family income). SES affects STEM career interest due to parental support, opportunities, and education given at home, and students with high SES tend to have good preparation for STEM, which positively affects their interests (Koyunlu Ünlü and Dökme 2020; Turner et al. 2019; Yerdelen et al. 2016).

In addition, parent education impacts parenting styles (Koyunlu Ünlü and Dökme 2020), and parents' education typically drives their occupations and incomes (Hascoët et al. 2021). Previous studies constructed models in which parents' education affects both parents' job and family income, and they

concluded that parents' education impacted household income (Davis-Kean et al. 2021; Hascoët et al. 2021).

Sahin et al. (2018) tested a model of factors that influence STEM career interest, and they found that personal factors (income and parents' education) have a direct effect on STEM career interest. Another study stated that students with higher SES had lower barriers to STEM careers and increased self-efficacy and outcome expectation, which positively affect STEM career interest (Turner et al. 2019). In addition, male students in private schools with high self-efficacy and high SES tend to select STEM careers (Ketenci et al. 2020), and female, black, Hispanic, and students from low SES are less likely to exhibit and cultivate interest in STEM careers during high school (Saw et al. 2018). Mau and Li (2018) concluded that race, gender, parents' education, family income, parents' occupation, mathematics interest, and science self-efficacy are the main predictors of STEM career interest. Recent studies have concluded that external factors (such as support from teachers and parents) and background factors (such as SES) affect students' interest in STEM career. Specifically 61% of studies in a systematic review reported background factors as a significant influence on students' STEM career interests (Chiu 2024; Msambwa et al. 2024).

Studies related to SES in influencing STEM career interest have been conducted in collectivist culture in Southeast Asia and other developing countries. Parents' education and occupations were found to influence Indonesian students' interest in STEM careers; however, the study was limited by a small sample size and the use of simple analyses (Siregar and Rosli 2021). Another study supports this finding, showing that parents and family significantly impact international Asian students' pursuit of STEM careers (Nguyen 2021). Conversely, contradictory results found that parents' education and job did not influence Cambodian and Kazakhstani students' interest in general STEM and science and engineering fields (Japashov et al. 2022; Sovansophal and Shimizu 2019), and another study concluded that there is no difference in STEM career interest based on parents' education and income (Koyunlu Ünlü and Dökme 2020). The authors suggest this may be because parents' education has a stronger influence on decisions to support children's university education in general, rather than specifically fostering interest in STEM fields (Sovansophal and Shimizu 2019).

According to these previous theories, we hypothesize that (1) mothers' and fathers' education, as well as family income, directly predict STEM career interest, and that (2) fathers' and mothers' education indirectly predict STEM career interest through family income.

Theoretical models. We developed two theoretical models in this study according to the results of the previous studies discussed above. Model 1 is a theoretical model that attempts to test motivational factors (self-efficacy and outcome expectation), cognitive factors (mathematics knowledge, science knowledge, and academic achievement), and SES factors (parents' education and income) on STEM career interest. Based on previous theories, these variables directly predict STEM career interest. Furthermore, some variables are indirectly associated with STEM career interest through mediators; (1) self-efficacy with outcome expectation as a mediator, (2) mothers' and fathers' education through family income, (3) mathematics and science knowledge through academic achievement, and (4) mathematics and science knowledge with self-efficacy as a mediator. This indicates that, for instance, students' self-efficacy might enhance their outcome expectation, which in turn increases their STEM career interest. This model was also used to empirically test the interests in

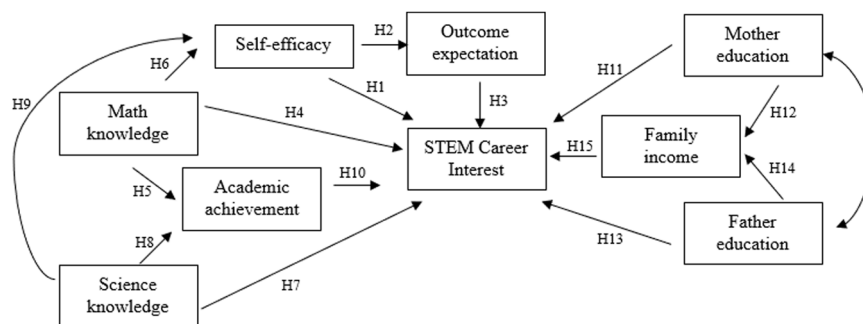


Fig. 1 Model 1: factors influencing STEM career interest and STEM discipline-specific.

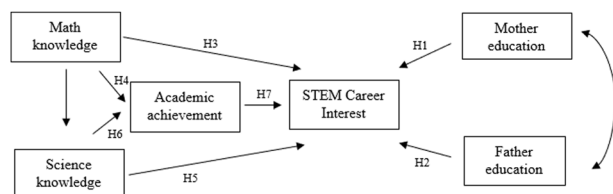


Fig. 2 Model 2: factors influencing STEM career interest and STEM discipline-specific.

science, mathematics, technology, and engineering careers separately. Figure 1 shows Model 1, which illustrates the influencing factors in STEM career interests and STEM discipline-specific career interest.

We obtained a fit model in Model 1 but it exhibited a marginal root mean squared error of approximation (RMSEA). Furthermore, we observed a large unexplained variation in family income variable (with more than 35% of the variance in this variable unexplained by the model). Consequently, we attempt to improve Model 1 to enhance the fit indices values and provide a complementary analysis. Therefore, Model 2 was constructed based on the empirical results obtained using Model 1 and a theoretical basis. Model 2 includes only cognitive and SES factors, excluding family income. We decided to omit the motivational factor and family income because it achieved a good and acceptable fit after analyzing several models that included the motivational factor. This decision aimed to balance how well the model explains the effect of certain factors on the outcome being studies with its statistical validity. Including the motivational factor may have introduced two or more factors in the model that are very similar or strongly related, making it hard to separate their individual effect, or made the model too specific to the data, thereby complicating the model structure. Furthermore, excluding the motivational factor helps confirm that the observed relationships in Model 1 are not overly dependent on the motivational factor.

In Model 2, we hypothesized variables such as mathematics knowledge, science knowledge, academic achievement, mothers' education, and fathers' education are predictors of STEM career interest. Furthermore, mathematics and science knowledge have indirect associations with STEM career interest through academic achievement. This indicates that mathematics and science knowledge might increase students' academic achievement, which hence enhances their interest in STEM career. Model 2 was also used to empirically test the interests in science, mathematics, technology, and engineering careers separately. Figure 2 shows Model 2, which considers the factors that predict STEM career interest and STEM discipline-specific career interest.

Methods

Instrumentation

STEM career interest questionnaire. The instrument used to measure STEM career interest, including self-efficacy and outcome expectation, was the adapted STEM career interest survey (STEM-CIS) (Kier et al. 2014), which is a five-point Likert scale questionnaire with 44 items, including 11 items for each STEM discipline-specific subscale (i.e., science, technology, engineering, and mathematics). Each STEM discipline-specific subscale assesses self-efficacy ($n = 8$), personal goal ($n = 8$), outcome expectation ($n = 8$), interest in the discipline ($n = 8$), contextual support ($n = 8$), and personal input ($n = 4$). The items in self-efficacy subscale measure beliefs about one's ability to complete a STEM tasks (e.g., I can get a good grade in my science class). The outcome expectation subscale assesses the consequence of taking action related to STEM (e.g., If I do well in science class, it will help me in my future career). The interest in the discipline subscale measures students' interest in STEM careers and classes (e.g., I am interested in careers that use science). The present study focuses primarily on self-efficacy and outcome expectation due to their significant relevance to existing literature, the results of preliminary analyses, and their theoretical importance in predicting STEM career interest. Hence, contextual support and personal input were excluded from the analysis.

The total score for the STEM career interest questionnaire is 220, with 55 points allocated to each discipline. In addition, the total score for each subscale is dependent on the number of items it contains, e.g., the total score for the self-efficacy subscale is 40.

Note that this questionnaire can be completed in 25 min, and it has good validity and reliability. The loading factor values range from 0.60 to 0.95, and the Cronbach alpha value of the questionnaire is 0.95, with 0.90, 0.90, 0.92, and 0.95 for science, mathematics, technology, and engineering, respectively. In addition, the Cronbach alpha values for self-efficacy, personal goal, expectation of outcome, interest, contextual support, and personal input in all disciplines or in general STEM discipline are 0.76, 0.80, 0.77, 0.79, 0.80, and 0.68, respectively.

Mathematics test. The mathematics tests include different tests for grades 10 and 11, which were developed by teacher unions. The contents of the tests were validated by four high school mathematics teachers (three females and one male) who obtained master's degrees in mathematics education and have more than four years of work experience. The tests are prepared in the Indonesian language and constructed according to the Indonesian mathematics curriculum and the background of Indonesian students.

The tests for grades 10 and 11 include 35 multiple choice questions, including simple questions and problem-solving questions. Note that students must complete these tests in

120 min using paper-based. The range of scores for the mathematics tests is from 0 to 100.

The grade 10 test covers the topics of roots and exponentials, arithmetic sequences and series, and geometric sequences and series. The test is reliable with a Cronbach alpha value of 0.81. An example of a problem-solving item is “E. coli bacteria cause diarrhea in humans. A researcher observed the development of 50 bacteria in food and found that each bacterium doubles in number every 15 min. Choose the correct graph that represents the growth of the bacteria” and an example of a simple item is “the simplest form of $(5\sqrt{x^5})(3\sqrt[3]{x})$ is”.

The test for grade 11 covers complex numbers, quadratic equations, system of equations (with three variables), polynomials, and matrices. This test has a Cronbach alpha value of 0.79. An example of the item is “The general form of the complex number of $-\frac{3+\sqrt{-4}}{2}$ is”.

Science test. Science subjects in high school are divided into basic physics, basic chemistry, and basic biology classes. Students must take these subjects. Thus, the science test encompasses physics, chemistry, and biology tests. The overall science scores are taken as the total score of the physics, biology and chemistry tests. The score range for each subject is 0 to 100; hence, the range of scores for science, which includes three subjects, is 0 to 300.

These tests were also developed by the science teachers' unions, and the content of the tests was validated by three high school teachers from the physics, chemistry, and biology disciplines. The physics and biology tests were validated by three female physics or biology teachers who graduated with a master's degree and have more than three years of work experience. The chemistry tests were validated by one male and two female chemistry teachers with more than three years of work experience. These tests are also prepared in the Indonesian language and constructed based on the Indonesian curriculum and the students' backgrounds. All tests in each grade include 35 multiple choice items in the form of simple and problem-solving questions. The student must complete each test in 120 min using the paper-based.

The grade 10 chemistry test assesses the topics of chemical bonding, compounding, and stoichiometry. This test is reliable with a Cronbach alpha value of 0.77. An example of the item is “An atom of element has 11 protons and 12 neutrons. What are the atom number and atomic mass of the element?”. The grade 11 chemistry test evaluates the topics of green chemistry, introduction to chemistry, atomic structure, chemical reactions, the mole concept, global warming, and solutions and their properties. This test is valid and reliable with a Cronbach alpha value of 0.76. An example of the item is “The pressure of ozone gas ($M_r = 48$) in a 3-liter container is twice the pressure of 14 grams of N_2 ($M_r = 14$). How many grams of ozone gas are in the container?”.

The grade 10 physics test assesses the topics of quantity (fundamental and derived), measurement, Newton force, inertia moment, density, work, and area. This test is reliable with a Cronbach alpha value of 0.77. An example of the item is “Select from the options below those that are classified as derived quantities”. The grade 11 physics test includes vector concepts, uniform linear motion, acceleration or deceleration of linear motion, velocity and acceleration, and projectile motion. The test is valid and reliable with a Cronbach alpha value of 0.71. An example of the item is “Three vectors A, B, and C have magnitude of 5 cm and are parallel, forming an angle of 45 degree with the positive x-axis. Determine the magnitude of $A + B + C$ ”.

The grade 10 biology test evaluates the topics of biodiversity, flora and fauna in Indonesia, and classification systems (plants and animals). This test is reliable with a Cronbach alpha value of

0.72. An example of the item is “Animals in Indonesia that are related to the Oriental and Australian regions are found in the Western and Eastern parts of Indonesia, Identify these animals”. The grade 11 test assesses the organization of living beings (cells, tissues, and organs), the human respiratory system, and the human movement system. This test is valid and reliable with a Cronbach alpha value of 0.74. An example of the item is “In animal cells, certain organelles play a role in directing the chromosomes towards the poles during cell division, these organelles are known as”.

Academic achievement. The academic achievement scores of the students are taken from their GPA in all subjects at the end of the first semester of 2023. The GPA is the mean score of all subjects taken by student, with scores ranging between 0 and 100. Note that the composition of the course depends on their interest; however, there are some compulsory courses, e.g., civic education, physical education, and religion study.

SES questionnaire. The SES questionnaire asks students to provide information about family income and parents' education. Family income is classified into four groups according to the average income in Indonesia. The educational levels of fathers and mothers are classified into six groups, including the primary (code = 1), middle (code = 2), high (code = 3), bachelor (code = 4), master (code = 5), and doctoral (code = 6) levels. The validation of the SES questionnaire was conducted by teachers prior to performing the data collection process.

Procedure. The author formally sent the ethical approval obtained from the Institutional Review Board of the University of Szeged, Hungary (reference number: 7/2022, issued on 5 July, 2022) to several schools prior to data collection. Schools were required to confirm participation within two weeks after receiving the ethical approval letter. The participating schools sent written informed consent to parents or guardians of students who provided detailed information about the study, including its purpose, procedure, and data confidentiality. After obtaining written informed consent from parents or guardians that stated given consent to participate in the study and consent to publish findings, schools generated a list of eligible participants. This list has been shared with the authors. The authors then coordinated with school leaders who confirmed their participation and discussed data collection considerations with the mathematics and science teachers. Before administering the instruments, the researcher and teachers requested verbal informed consent from the students, emphasizing the voluntary nature of participation. Students were informed that they had the option to withdraw from the study at any time with no consequences. All students who gave consent from themselves and their parents are included in the study.

The students took the mathematics and science (physics, chemistry, and biology) tests on the first four days of the data collection process, one test in each day. On the fifth day, the students completed the STEM career interest questionnaire and provided the requisite SES information. The data collection process was conducted between November 01, 2023 and January 31, 2024. The data from the students were then analyzed to examine the factors that predict STEM career interest and STEM discipline-specific career interest.

Participants. We employed a stratified random sampling method. We established criteria for selecting schools and randomly chose both schools, that satisfied the criteria, and students based on their and their parents' consents. The study was carried

Table 1 Demographic profile of student participants.

Demographic Characteristics		N	%
Grades	10 (M age = 15.53, SD = 0.59)	288	39.02
	11 (M age = 16.52, SD = 0.57)	450	60.98
Gender	Male	289	38.80
	Female	452	61.20
School type	Public school	544	73.70
	Private school	152	20.60
	Vocational school	42	5.70
Major	Social	170	23.04
	Pharmacy and Clinical pharmacy	32	4.34
	Science	455	61.65
	Medical engineering	7	0.95
	Health analyst	6	0.81
	Social-Science	50	6.78
	Informatics and technology	2	0.27
	Language	16	2.17
School location	Urban	313	42.41
	Rural	425	57.59
Ethnicity	Javanese	641	86.90
	Malay	66	8.90
	Others	31	4.20

out in Indonesian high schools in the provinces of Java and Sumatera, from both urban and rural areas. These provinces were selected because they have implemented the new curriculum called “Merdeka” curriculum, which emphasizes and integrates STEM education. Schools were selected based on their application of the “Merdeka” curriculum and their A-accreditation status. A-accreditation is a crucial criterion as it represents the schools’ commitment to the “Merdeka” curriculum. There are 3912 schools in Java and Sumatera that have A-accreditation and implement the “Merdeka” curriculum, with the total number of 1,173,600 students in grade 10 and 11. These schools include public, private, and vocational schools.

Students in public, private, and vocational schools must choose their major at the beginning of high school based on their entrance test scores and interests. However, in public and private schools, major options are limited to social, science, and language. Vocational schools offer a wider variety of majors, depending on the school. Students cannot change their major during high school. All students, regardless of their major, are required to take mathematics and basic science courses (including basic physics, chemistry, and biology).

Given the total population, with a confidence level of 99% and margin of error of 5%, the minimum sample required for the study is 666. We included 738 student participants, making the sample representative of the population. Table 1 shows the demographic profile of the student participants.

Analysis. In this study, we examined the role of the independent variables (i.e., self-efficacy, outcome expectation, mathematical knowledge, science knowledge, academic achievement, family income, and parents’ education) on STEM career interest. We also investigated the association of these independent variables on STEM discipline-specific career interest. This study relies on quantitative data, using structural equation modeling (SEM) with an estimator of maximum likelihood, with correlations and standard deviation data types. The SEM analysis was completed using the Mplus software (version 8.4).

We included data from 738 students out of the initial 1034 participants due to dropout during the data collection process and data exclusion. On the first day, 1034 students participated (446 grade 10 and 588 grade 11 students). However, some students dropped out over the data collection: 22 grade 10 and 35

grade 11 students on the second day, 33 grade 10 and 29 grade 11 students on the third day, and 27 grade 10 and 16 grade 11 students on the fourth day. By the fifth day 357 grade 10 and 476 grade 11 students remained and completed the data collection process. After reviewing the data, 95 students (69 grade 10 and 26 grade 11) were excluded due to incomplete responses and extreme outliers. Hence, data from the remaining 738 students were analyzed for this study.

We developed two theoretical models on the effect of these factors on STEM career interest. Here, to ensure the fit of the model, we investigated the Chi-squared test values, the comparative fit index (CFI), the Tucker–Lewis index (TLI), the RMSEA, and the standardized root mean square residual (SRMR). The cutoff points for the CFI and TLI are 0.95; however, they are still deemed acceptable with a value of approximately 0.90 (Hu and Bentler 1999). In addition, good SRMR and RMSEA values are less than 0.08 (Hu and Bentler 1999); however, they are considered marginal if they are in the range [0.08, 0.10] (Fabrigar et al. 1999). After fitting the models, we analyzed the independent variables that predict STEM career interest and STEM discipline-specific career interest based on the significant values and regression coefficients, and we identified the standardized estimates regarding their direct effect, indirect effect, and the total effect for all independent variables.

Results

Descriptive statistics. Students’ STEM career interest is categorized as high (or $M > 50\%$). Similar cases were reported in the STEM discipline-specific subscale, i.e., students showed high career interest in science, mathematics, technology, and engineering, with the lowest score in the engineering discipline. According to the SCCT subscale, the scores for self-efficacy ($M = 28.14$, $SD = 5.17$), personal goal ($M = 29.81$, $SD = 5.63$), outcome expectation ($M = 30.02$, $SD = 5.30$), interest in disciplines ($M = 28.06$, $SD = 5.72$), contextual supports ($M = 27.21$, $SD = 6.16$), and personal input ($M = 13.62$, $SD = 3.16$) were also high. The students’ performance in science and mathematics knowledge revealed that they passed 75% of the total score, and the mathematics scores were lower than the science scores.

We also present findings on the variability and relationships among the observed variables derived from the data using standard deviation and correlation to infer causality. Table 2 shows the results of correlations, means, and standard deviations of each variable.

As can be seen, most variables are significantly correlated with high correlation coefficients; however, some variables are not significantly correlated, e.g., the correlation between mathematics career interest and father’s education, mother’s education, and family income. The strongest correlation was between the science knowledge score and interest in science careers ($r = 0.92$). We observed in Table 2 a weak correlation or a correlation below 0.4, which result in an insignificant effect in the structural model. For example, the correlation between academic achievement and mathematics career interest was 0.27. The results of ceiling effect revealed a small percentage of students (between 0% and 5%) achieved the maximum score. This shows that a ceiling effect is not present.

Goodness-of-fit indices. The results of the goodness-of-fit indices demonstrated that Model 1 for both STEM career interest and STEM discipline-specific career interest had an issue with the high RMSEA value or acceptable value but categorized as marginal. However, all CFI, TLI, and SRMR values were acceptable. In addition, the values of the goodness-of-fit indices for STEM career interest model showed similar results with STEM

Table 2 The results of correlations and standard deviations of each variable.

	STEM	S	M	T	E	SK	MK	ME	FE	FI	AA	SE	OE
STEM	1												
S	0.73**	1											
M	0.76**	0.55**	1										
T	0.77**	0.37**	0.41**	1									
E	0.79**	0.34**	0.38**	0.59**	1								
SK	0.67**	0.92**	0.53**	0.35**	0.30**	1							
MK	0.70**	0.53**	0.90**	0.36**	0.36**	0.53**	1						
ME	0.17**	0.15**	0.06	0.22**	0.09*	0.13**	0.06	1					
FE	0.09*	0.11**	0.02	0.13**	0.03	0.09*	0.01	0.60**	1				
FI	0.09*	0.13**	0.01	0.11**	0.04	0.11**	0.01	0.51**	0.45**	1			
AA	0.34**	0.32**	0.27**	0.28**	0.19**	0.40**	0.30**	0.07**	0.07**	0.10**	1		
SE	0.87**	0.67**	0.68**	0.65**	0.66**	0.63**	0.62**	0.13**	0.07**	0.07	0.32**	1	
OE	0.89**	0.66**	0.67**	0.71**	0.68**	0.60**	0.60**	0.16**	0.08*	0.07	0.31**	0.70**	1
Means/ Modes	156.85	39.97	38.47	42.66	35.75	237.71	77.35	3.00	3.00	4.50	84.63	28.14	30.02
SD	27.43	8.61	8.63	8.25	10.45	30.24	12.00	-	-	-	7.30	5.17	5.30

STEM STEM career interest, S science career interest, M mathematics career interest, T technology career interest, E engineering career interest, SK science knowledge, MK mathematics knowledge, ME mothers' education, FE fathers' education, FI family income, AA academic achievement, SE self-efficacy, OE outcome expectation.
**p < 0.01; *p < 0.05.

discipline-specific career interest models. Table 3 shows the results of the goodness-of-fit indices for Models 1 and 2 in terms of STEM career interest and STEM discipline-specific career interest.

We tried to improve the goodness-of-fit indices by developing a similar model with fewer variables, i.e., Model 2. Here, self-efficacy, outcome expectation and family income variables were excluded from the model. The results of Model 2 in terms of STEM career interest and in STEM discipline-specific career interest indicated that the model showed good fit. Here, all categories of the fit indices were greater than the cutoff points, and the goodness-of-fit indices for Model 2 were better than those for Model 1 in all disciplines, as shown in Table 3.

Estimates of structural models. The results of Model 1 demonstrated that the SES factor was not a significant predictor of career interest. Here, we found that the cognitive and motivational factors significantly predicted interest in STEM careers. For example, outcome expectation and self-efficacy were the strongest predictors of STEM career interest, which was followed by the cognitive factors, i.e., mathematics and science knowledge. However, surprisingly, academic achievement and SES did not significantly associate with the students' interest in general STEM careers.

Different results were observed for the factors that predict science career interest. Here, we found that science knowledge was the strongest predictor, which means that students with high science knowledge tend to choose a science-related career. In addition, both outcome expectation and self-efficacy significantly associated with interest in science careers with low regression coefficients. Academic achievement was found to have a negative regression coefficient on the interest in science careers. This indicates that students with high academic achievement did not have an interest in science careers. The mathematical knowledge and SES factors did not contribute to the factors that predict the students' interest in science careers.

Unlike the factors that predicted interest in science careers, mathematics knowledge was the strongest factor predicting student interest in mathematics careers. In addition, academic achievement was found to have a weak negative regression coefficient, or students with high academic achievement tend to avoid careers involving mathematics. Self-efficacy and outcome expectation were found to weakly contribute to students' choice in mathematics-related careers. Both science knowledge and SES factors were not found to significantly predict students' mathematics career interest.

We found that outcome expectation and self-efficacy had the strongest effect in terms of predicting the choice in technology-related careers. However, knowledge of science and mathematics was reported to have negative regression coefficients, which means that students with good science and mathematics knowledge tend to avoid technology-related careers. Academic achievement and mothers' education had weak effects in predicting students' interest in technology careers; however, the father's education and family income did not associate with student interest in technology-related careers.

Similar results were observed for interest in engineering careers, with outcome expectation and self-efficacy having the highest regression coefficient. Mathematics and science knowledge had negative regression coefficients. However, all of the SES factors and the academic achievement factor did not predict student interest in engineering careers.

The results of the factors that predict STEM career interest in Model 2 revealed that mathematics knowledge had the highest regression coefficient, followed by science knowledge. These

Table 3 Results of goodness-of-fit indices of Models 1 and 2.

	STEM	Science	Mathematics	Technology	Engineering
Model 1					
Parameter estimated	23	23	23	23	23
Chi square	$\chi^2 (19) = 142.75$, $p < 0.001$	$\chi^2 (19) = 142.75$, $p < 0.001$	$\chi^2 (19) = 142.75$, $p < 0.001$	$\chi^2 (19) = 142.75$, $p < 0.001$	$\chi^2 (19) = 142.75$, $p < 0.001$
CFI	0.96	0.95	0.96	0.94	0.94
TLI	0.94	0.93	0.93	0.91	0.91
RMSEA	0.09	0.09	0.09	0.09	0.09
SRMR	0.08	0.08	0.07	0.08	0.08
Model 2					
Parameter estimated	14	14	14	14	14
Chi square	$\chi^2 (6) = 15.03$, $p < 0.05$	$\chi^2 (6) = 15.03$, $p < 0.05$	$\chi^2 (6) = 15.03$, $p < 0.05$	$\chi^2 (6) = 15.03$, $p < 0.05$	$\chi^2 (6) = 15.03$, $p < 0.05$
CFI	0.99	0.99	0.99	0.98	0.98
TLI	0.98	0.99	0.99	0.97	0.96
RMSEA	0.05	0.05	0.05	0.05	0.05
SRMR	0.05	0.05	0.05	0.05	0.04

findings demonstrate that students with high mathematics and science knowledge tend to be interested in STEM careers. In addition, the mothers' education was found to be a weak predictor of student interest in STEM careers. However, we found that the fathers' education and academic achievement did not significantly associate with interest in STEM careers.

Similar to the results of Model 1 in terms of students' interest in science careers, student knowledge in science was the strongest predictor predicting career interest in science, and mathematics knowledge also contributed to interest in science careers. However, academic achievement had a negative regression coefficient, which means that students with high academic achievement tend to avoid careers in science-related fields. Furthermore, the SES factors did not significantly predict student interest in science careers.

Only mathematics and science knowledge significantly predicted students' interest in mathematics and engineering careers. Here, mathematics knowledge was the strongest predictor affecting student interest in mathematics career. However, mathematics knowledge was a weak predictor of interest in engineering-related careers. We also found that science knowledge had a small contribution in terms of predicting student interest in mathematics and engineering careers.

The strongest factor influencing interest in a technology-related career was the mathematics knowledge of the students. Other factors that predict interest in technology careers included science knowledge, academic achievement, and mothers' education. However, these factors only weakly predicted interest in technology careers due to low regression coefficients. Table 4 informs the standardized estimates of Models 1 and 2.

Mediating effect of structural models. The results of the mediating effect in Model 1 revealed that self-efficacy predicts student interest in STEM careers indirectly through the outcome expectation, with a regression coefficient of 0.35. In addition, self-efficacy was also a mediator of the relationship between mathematics knowledge ($\beta = 0.17$) or science knowledge ($\beta = 0.18$) and students STEM career interest.

We observed a similar pattern in the mediating effect of the variables that predict science and mathematics career interests. Here, mathematics and science knowledge indirectly associated with mathematics and science career interest through self-efficacy with low regression coefficients. In addition, outcome expectation was also a mediator of the relationship between self-efficacy and

career interests in science and mathematics. However, we found negative regression coefficients of the indirect effect of science and mathematics knowledge on science and mathematics career interests through academic achievement because students with high academic achievements tend to avoid mathematics and science careers.

Self-efficacy was found to be the strongest indirect factor predicting technology career interest through outcome expectation ($\beta = 0.41$). Students with high self-efficacy tend to have a high outcome expectation, which associates with student interest in technology careers. Mathematics knowledge predicted technology career interest indirectly through both academic achievement and self-efficacy, and the same case revealed that science knowledge indirectly predicted technology career interest through self-efficacy and academic achievement.

Self-efficacy was found to strongly predict interest in engineering careers through outcome expectation ($\beta = 0.40$). Other variables with indirect effects on interest in engineering careers included mathematical knowledge and science knowledge through self-efficacy.

In Model 2, the results revealed that there are no significant indirect associations between exogenous variables and interest in STEM careers, mathematics careers, and engineering careers. However, mathematics and science knowledge were found to predict interest in science-related careers through academic achievement with negative regression coefficients. These findings demonstrate that students with high mathematical knowledge and science knowledge tend to have high academic achievement; however, students with high academic achievement exhibit no interest in science-related careers. Mathematics and science knowledge weakly predicts interest in technology careers through academic achievement. Table 4 shows the detailed results for the mediating effect of structural Models 1 and 2.

Discussion

This study provides comprehensive models that integrate motivational, cognitive, and SES factors influencing STEM career interest using advanced analyses that address the gaps of previous studies in Southeast Asia. Model 1 was found to be a fit model; however, the RMSEA value was classified as marginal (Fabrigar et al. 1999; Hu and Bentler 1999). RMSEA is related to model complexity; hence, the high RMSEA is because of few degrees of freedom. RMSEA is meaningless with the few degree of freedom; thus, the decision on the fit model was based on the CFI and

Table 4 Standardized estimates and mediating effect of Models 1 and 2.

Exogenous variables	Endogenous variables											
	STEM			Science			Mathematics			Technology		
	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total
Model 1												
MK → AA	0.11*	-0.00	0.13	-0.02	-0.01*	-0.03	0.77*	-0.01*	0.77*	-0.18*	0.01*	-0.17*
MK → SE	0.05*	0.17*	0.29*	0.83*	0.04*	0.02	-0.04	0.05*	0.82	-0.25*	0.18*	0.00*
SK → AA		-0.00	0.05		-0.02*	0.81*		-0.01*	-0.05		0.03*	-0.22*
SK → SE		0.18*	0.23*		0.04*	0.87		0.05*	0.02		0.18*	-0.06*
AA → SE	-0.00	-	-0.00	-0.07*	-	-0.07*	-0.04*	-	-0.04*	0.09*	-	0.01
SE → OE	0.43*	0.35*	0.78*	0.10*	0.10*	0.19*	0.13*	0.11*	0.24*	0.44*	0.41*	0.86*
OE → FI	0.50*	-	0.50*	0.14*	-	0.14*	0.16*	-	0.16*	0.59*	-	0.59*
FI → ME	0.02	0.02	0.02	0.03	-	0.03	-0.00	-	-0.00	0.00	-	0.02
ME → FI	-0.00	0.00	-0.00	0.02	0.01	0.02	0.01	-0.00	0.01	0.01	0.00	0.01
ME → FI	0.01	0.01	0.15	-0.01	0.01	0.01	-0.02	-0.00	-0.02	0.10	0.00	0.10
Model 2												
MK → AA	0.47*	0.01	0.48	0.07*	-0.01*	0.04*	0.87*	-0.00	0.87	0.23*	0.02*	0.25*
SK → AA	0.40	0.01	0.41	0.91*	-0.02*	0.89*	0.07*	-0.01	0.07	0.15*	0.05*	0.20*
AA → SE	0.04	-	0.04	-0.06*	-	-0.06*	-0.02	-	-0.02	0.14*	-	0.14*
FE → ME	-0.01	-	-0.01	0.02	-	0.02	0.00	-	0.00	-0.01	-	-0.01
ME → SE	0.09	-	0.09	0.02	-	0.02	-0.00	-	-0.00	0.19*	-	0.19*

“-” shows there is no path between these variables.
STEM STEM career interest, S science career interest, M mathematics knowledge, MK mathematics knowledge, ME mothers’ education, FE fathers’ education, FI family income, AA academic achievement, SE self-efficacy, OE outcome expectation.

SRMR values (Kenny et al. 2015). In this study, the degree of freedom of Model 1 was small; therefore, we neglected the RMSEA results and concluded that the model was fit based on the obtained CFI and SRMR values. Model 1 is generally robust, and the discussion of the results is important because it highlights the significant role of motivational factors. Model 1 also provides a comprehensive understanding of how motivational factors interplay with SES and cognitive factors. However, we attempt to construct Model 2 for further examination due to the marginal RMSEA of Model 1. Furthermore, refining the model into Model 2 is a methodological step to ensure that the results are not model-specific. This also helps verify whether SES and cognitive factors still hold significant predictive power in the absence of motivational factor.

We excluded motivational factor in Model 2 to balance the model’s ability to explains the effect of certain factors on the outcome with its statistical validity. Including the motivational factor might have created overlap between variables (multi-collinearity), making it difficult to distinguish each variable’s individual effect. Additionally, including motivational factors could make the model too specific to this sample, limiting its general usefulness. Although theoretical frameworks strongly support motivational factors as predictors, the empirical data in this study did not yield a satisfactory model fit when these factors were included. This may be due to measurement and sample-specific issues. Motivational factors were assessed through self-report, and Indonesian students tend to overrate themselves or choose high ratings without carefully reading the statements.

The strongest factor predicting interest in STEM careers was outcome expectation ($\beta=0.50$), followed by self-efficacy ($\beta=0.43$). These findings align with previous studies, where outcome expectation and self-efficacy strongly associated with interest in STEM career interest with regression coefficients greater than 0.30 (Garriott et al. 2014; Luo et al. 2021; Mohtar et al. 2019; Sahin et al. 2018; Turner et al. 2019). The results of this study align with findings from other collectivist countries, where outcome expectations have a stronger effect than self-efficacy on STEM career interest (Alam et al. 2021; Nakamura 2015). This may be because, in collectivist cultures, individuals tend to consider how their career choices will impact family and community, prioritizing collective benefits and social expectation (e.g., financial stability, societal respect and approval) over confidence in their own abilities. Although the findings were similar to previous studies in Southeast Asia, this study provides a comprehensive analysis of the effects of self-efficacy and outcome-expectation in comparison to several factors. However, this finding contrasts with findings in Western culture, where self-efficacy has a stronger effect than outcome expectations on STEM career interest (Garriott et al. 2014; Luo et al. 2021).

Mathematics and science knowledge weakly associated with interest in STEM careers. These results are consistent with those of previous studies that have shown discipline knowledge (mathematics, science, and research) has an effect on student interest in STEM careers (Adedokun et al. 2013; Balta et al. 2023; Fong and Kremer 2020; Wang et al. 2015). However, several previous studies have observed strong effects of discipline knowledge on career interest (Adedokun et al. 2013; Wang et al. 2015), and these observations do not align with the findings of the current study. Additionally, several studies in collectivist cultures have found that achievement in science and mathematics strongly impacts students’ interest in STEM career, which contrasts with the findings of this study (Balta et al. 2023; Sovansophal and Shimizu 2019). The reasons are likely due to: (1) Indonesian curriculum, teaching methods, or societal value placed on these subjects might not be as strongly linked to career aspirations in STEM; hence students do not see mathematics and sciences as

directly leading to job opportunities in STEM fields; and (2) Motivational factors might outweigh the role of mathematics and science skills in Indonesia. Hence, it is possible that differences in participant characteristics and external factors contribute to varying results among collectivist countries. The findings regarding the weak effect of mathematics and science knowledge in this study provide novelty in both Southeast Asian and Western contexts by highlighting how these factors interact when analyzed alongside others. In contrast, previous studies were reported strong effects because they focused only on cognitive factors without considering influential factors such as motivational factor.

SES and academic achievement did not predict student interest in STEM careers. Previous studies in collectivist cultures have reported similar results in terms of the lack of contribution of SES to student interest in STEM careers (Japashov et al. 2022; Koyunlu Ünlü and Dökme 2020). The lack of contribution of academic achievement and SES in student STEM career interest is predicted because academic achievement comprises STEM and nonSTEM grades; thus, students with high academic achievements may master nonSTEM courses. Another reason is that SES predicts interest in STEM careers at an early age (Yerdelen et al. 2016); thus, this factor did not significantly predict student interest in STEM careers in the high school context. However, SES, specifically mothers' education, predicted students' interest in technology careers. This finding aligns with previous study indicating that in collectivist cultures like Indonesia, mothers' education predict students' decision regarding both general STEM careers and discipline-specific choices, since in such cultures, students prioritize group harmony, familial obligations, and collective well-being over personal achievements (Bahar and Adiguzel 2016).

Self-efficacy also strongly associated with STEM career interest indirectly through outcome expectation, aligning with findings from several previous studies in both Western and collectivist cultures (Alam et al. 2021; Garriott et al. 2014; Luo et al. 2021; Turner et al. 2019). In addition, the results observed for the indirect effect of mathematics and science knowledge on interest in STEM careers through self-efficacy in the current study agree with the SCCT. This finding contributes to studies in Southeast Asian context by addressing the lack of analysis on the potential indirect effects of cognitive factors in influencing STEM career interest.

Similar findings were observed in terms of the factors that predict interest in STEM careers in the results of the factors influencing STEM discipline-specific career interest, with motivation and cognitive factors being significant predictors (both directly and indirectly). This detail observation of similarities and differences in discipline-specific STEM career interest addresses the gaps in previous studies within both Southeast Asian and Western contexts. In the following, we report the similarities and differences in Model 1 for each STEM discipline-specific career interest. The similarities are summarized as follows. (1) Outcome expectation and self-efficacy directly predicted career interest. The effects on career interest in science and mathematics were weak, and they became the strongest predictors of interest in technology and engineering careers. The findings contrast with studies from collectivist cultures, which report that self-efficacy strongly influences science career interest (Mohtar et al. 2019; Sovansophal and Shimizu 2019). The effects of self-efficacy and outcome expectation on mathematics and science career interest were weak because the science and mathematics curricula in Indonesia schools are quite rigorous and theoretical, which might make these subjects less appealing to some students compared to the more practical-oriented fields of technology and engineering. Furthermore, careers in pure science and mathematics seem more

abstract and less immediately rewarding to students. The pathways to success in these fields can appear longer and less certain, causing to weaker outcome expectation. (2) No direct significant association was observed for the father's education and family income on the discipline-specific career interest, which aligns with studies from collectivist culture (Japashov et al. 2022; Sovansophal and Shimizu 2019). However, this contrasts with some studies from collectivist culture, where parents' education influences STEM career interest (Nguyen 2021; Siregar and Rosli 2021). The reason is possibly due to the study population comprises A-accreditation schools, which offer relatively uniform access to resources and opportunities across different income level. Furthermore, cultural norms that emphasize collective decision-making and community influences may overshadow the direct association of father's education and income. (3) No indirect association was observed in terms of the parents' education through family income on the discipline-specific career interest. (4) Outcome expectation was a moderator in the relationship between self-efficacy and discipline-specific career interest. Here, the effects in terms of interest in science and mathematics careers were weak, and they became the strongest indirect effects for interest in technology and engineering careers. (5) Mathematics and science knowledge indirectly predicted discipline-specific career interest through self-efficacy with weak regression coefficients (less than 0.30).

The observed differences are summarized as follows. (1) Science knowledge was the strongest predictor of interest in science-related careers, and there was no significant effect on mathematics career interest. This finding is possible because a career in science requires mastery of science knowledge, while a career in mathematics demands proficiency in mathematics knowledge. Students with strong knowledge in science and mathematics tend to have high confidence in pursuing these careers (Balta et al. 2023; Wang et al. 2015). (2) Mathematics knowledge was the main predictor of student interest in mathematics careers; however, there was no significant effect in science career interest. (3) Students with high mathematics and science knowledge tend to avoid technology and engineering careers. The reason is likely that students with high knowledge in mathematics and science tend to prefer work environments associated with these fields. (4) Academic achievement only predicted science, mathematics, and technology career interests; however, we found negative regression coefficients relative to interest in science and mathematics careers. (5) The mothers' education exhibited a weak effect on technology career interest. Mother with higher education in Indonesia might be more aware of the growing opportunities and importance of technology fields, thus encouraging their children to pursue career in technology. Mother education is the only SES factors predicting technology career interest, likely because Indonesian mothers often play a more direct role in their children's education and career guidance, while fathers may be perceived more as breadwinners rather than educators. (6) Science and mathematics knowledge indirectly predicted interest in mathematics, science, and technology careers through academic achievement. Science and mathematics exhibit more similarities and differences compared to technology and engineering. In Indonesian high schools, science and mathematics courses are more highly valued than engineering and technology courses. Technology is often seen as a tool to facilitate students' learning in these courses. Figure 3 explains the similarities and differences of the results of the final Model 1 in STEM and discipline-specific career interest.

The goodness-of-fit indices for Model 1 were improved by constructing Model 2. The results revealed that Model 2 exhibited acceptable and better fit indices compared to Model 1 (Hu and Bentler 1999). Here, mathematics knowledge was found to be the

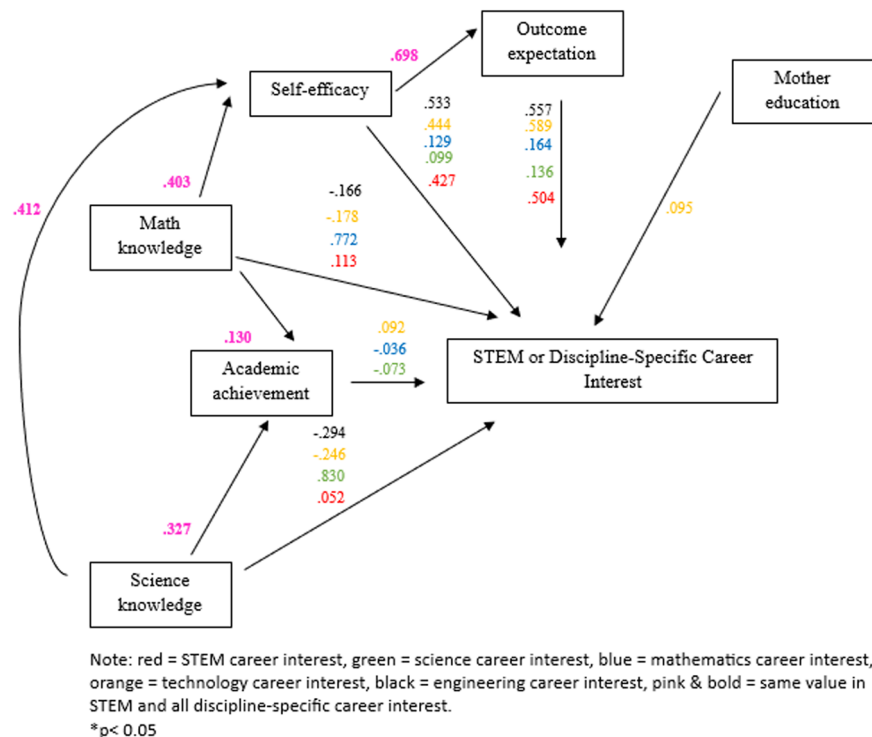


Fig. 3 The similarities and differences of the results of Model 1 in STEM and discipline-specific career interests.

strongest predictor of interest in STEM careers, and this was followed by science knowledge, which is consistent with the findings of a previous study (Wang et al. 2015). However, the mothers' education was found to have only a weak effect on student interest in STEM careers. Although, mothers' education has a weak association, it still plays a role in predicting STEM career interest among students from collectivist culture that is consistent with the finding of previous study (Bahar and Adiguzel 2016). In addition, no indirect factors were observed to predict interest in STEM careers, mathematics careers, and engineering careers.

According to the results of Model 2, we found similar results in all STEM discipline-specific career interests, i.e., mathematics and science knowledge directly predicted student interest in discipline-specific careers. Here, mathematics knowledge was the strongest predictor of student interest in mathematics, engineering, and technology careers, and science knowledge was the strongest predictor of interest in science-related careers. However, we also detected the following differences: (1) students with high academic achievement tend to avoid science careers; (2) academic achievement and the mother's education associated with student interest in technology-related careers; (3) science and mathematics knowledge indirectly predicted interest in technology careers through academic achievement; and (4) science and mathematics knowledge indirectly predicted interest in science-related careers through academic achievement with a negative regression coefficient. Figure 4 informs the similarities and differences of the results of the final Model 2 in STEM and discipline-specific career interest.

According to the results of Models 1 and 2, cognitive factors and mother's education remain significant predictors even in the absence of motivational factor. However, when analyzed together, motivational factors emerge as the most important factor predicting students' STEM career interest.

This study involved some limitations in terms of the sample proportion, the instrument used, and the limited exogenous

variables. For example, this study only evaluated motivational, cognitive, and SES factors; however, several other factors can potentially predict student interest in STEM careers, such as contextual factors (e.g., parental support, STEM activities, and STEM stereotype) and personal factors (e.g., gender). Future research could incorporate these factors to gain a more comprehensive understanding of what influences students' career interest. In addition, the motivational factor only includes self-efficacy and outcome expectation; however, other motivational factors, e.g., interest in disciplines and personal goals, should also be assessed. Expanding this to include other motivational factors, such as interest in specific disciplines and personal goals, could offer more insight into what drives students toward STEM fields. Additionally, further studies can refine motivational factors (self-efficacy and outcome expectation) by adjusting the assessment used to measure them (e.g., using different scales or ways of assessing them) and revising how these factors are incorporated into the model (e.g., testing their interactions with other variables) rather than omitting motivational factors. Furthermore, a limitation using self-reported data to measure motivational factors may introduce bias.

The SES factor only includes family income and parents' education, and we did not find any significant effect of these variables. This might be because the measurement of parents' education is quite broad or general in nature and may inadequately reflect the multifaceted aspect of parental education. Thus, it is important for future studies to specify the category of the parents' education, e.g., the discipline of their study or the depth of their STEM knowledge. Additionally, there are several possible SES variables that could have a strong effect to be included in subsequent research, e.g., the occupations of the parents, community supports. By improving the ways to assess SES and incorporating a broader range of SES factors, future studies can provide a more comprehensive understanding of how SES factors influence STEM career interest. Regarding the cognitive factor, we did not measure students' knowledge in

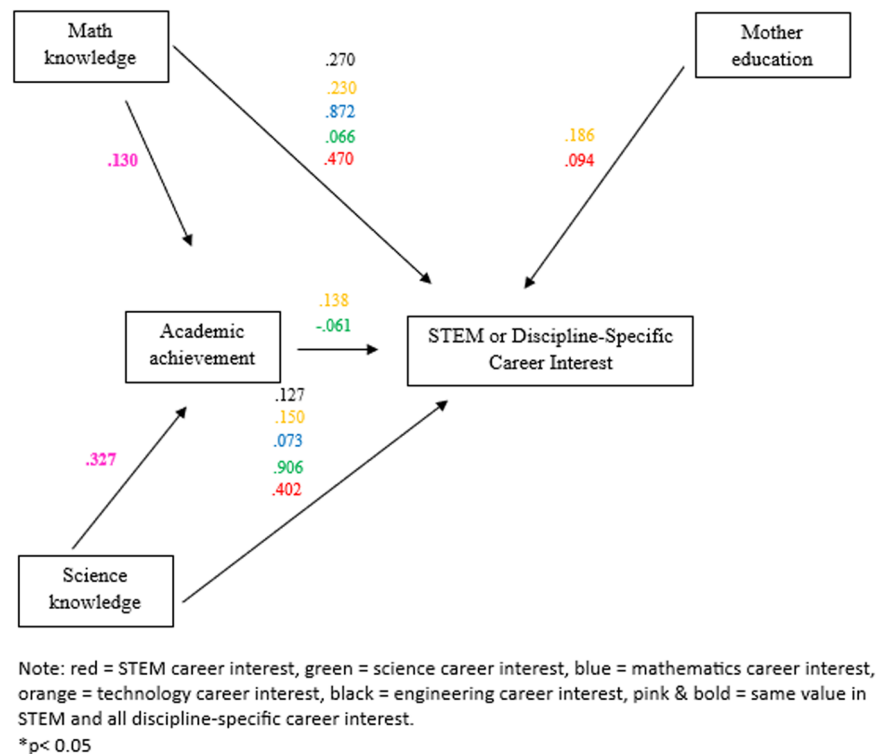


Fig. 4 The similarities and differences of the results of Model 2 in STEM and discipline-specific career interests.

technology and engineering, unlike in mathematics and science. These two factors most probably explain the strong relationship in students' interest in STEM. Including assessments of technology and engineering knowledge in future studies could provide a more complete picture of how cognitive factors influence students' interest in STEM career. Thus, further study should include a wider variety of relevant variables using more precise instruments.

Another limitation is related to the proportion of the sample based on grade, gender, school type, and major. An inappropriate proportionality of the sample could affect the results; thus, the use of a proportional sample in each group is recommended. The overrepresentation of certain categories, such as students from public schools and the Javanese ethnic group, may limit the generalizability of the findings to the broader population of high school students in Indonesia. In addition, this could influence the findings, for example, students from public schools might have different resources and educational experiences compared to those from private or vocational schools, which could influence their interest in STEM careers differently. Ensuring a more balanced sample in future research could enhance the applicability of the findings. In addition, we suggest that future studies evaluate the model based on gender differences because the issue of gender differences is crucial in STEM education, and we consider that gender differences could predict the factors that predict student interest in STEM careers.

Lastly, a limitation of the SEM model in the present study is that it doesn't include a measurement model, and interest in each discipline subscale is measured by only two items. Therefore, future studies should incorporate a measurement model in the SEM framework and expand the subscale for interest in each discipline.

Despite the limitations, the results of this study provide valuable insights from both education and social perspectives. Given that motivational factors are the most influential in determining STEM career interest, initiatives aimed to boosting motivation,

specifically self-efficacy and outcome expectation, such as mentorship program, STEM-related extracurricular activities, and role models, could be crucial. Policymakers could develop programs that enhance motivational factors from early education stages, ensuring sustained interest in STEM careers. Schools and educators can integrate engaging and inspiring STEM content into the curriculum, making it more interactive and relatable to students' lives. In addition, training educators to recognize and nurture students' interest in STEM can help maintain and grow their motivation over time.

Cognitive factors are also crucial factors in predicting students' STEM career interest. Providing cognitive development programs, specifically in mathematics and science, and early exposure to STEM concepts will be beneficial. In addition, providing additional support service, such as tutoring and counseling, can help students overcome cognitive challenges and succeed in STEM areas.

Mother's education is the only SES factor predicting students' STEM career interest. Hence, it is beneficial to implement a program that involves mothers in their children's education (e.g., workshop) and provide them with resources and support to foster a conducive learning environment at home. For policymakers, it is beneficial to develop initiatives that enhance educational opportunities for mothers as a strategy to improve their children's educational outcome and interest in STEM.

Conclusion

This study has examined two models, i.e., Model 1 (with cognitive, motivational, and SES factors), and Model 2 (with cognitive and SES factors). Both models fit well, but Model 2 exhibited better goodness-of-fit indices. Our findings indicate that both cognitive and motivational factors are crucial factors that predict student interest in pursuing STEM careers and STEM discipline-specific careers. The mother's education was the only SES factor predicting interest in specific careers, e.g., interest in technology careers. Comparing the results of Model 1 and Model

2, cognitive factors and mother's education continue to be significant predictors even in the absence of motivational factor.

The motivational factors (self-efficacy and outcome expectation) were the strongest predictors when analyzed together with all variables (i.e., Model 1) in both STEM career interest in general and in each discipline-specific career interest. Science and mathematics knowledge were the strongest predictors for their respective fields but were weak predictors of general STEM interest and negatively correlated with technology and engineering careers. Students with highly educated mothers tended to show more interest in technology careers. Furthermore, indirect relationships were observed in both general STEM career interest and discipline specific career interests: (1) self-efficacy through outcome expectation; and (2) mathematics and science knowledge through self-efficacy both with weak regression coefficients. Finally, science and mathematics knowledge indirectly predicted in science, mathematics, and technology career interests through academic achievement.

The cognitive factor, except academic achievement, become the most important factor when evaluated in combination with the SES factors (i.e., Model 2). Mathematics and science knowledge emerged as the strongest predictors of interest in mathematics- and science related-career, respectively. Mother's education was only a weak predictor of student interest in STEM and technology careers. Furthermore, academic achievement was associated only with technology career interest. Crucial indirect effects were found only between mathematics and science knowledge and technology career interest through academic achievement. These results are influenced by the curriculum in Indonesia and collectivist cultural values.

We expect that the findings of this study will be beneficial to teachers as a foundation to design effective interventions for students to improve their interest in pursuing STEM careers by focusing on the most influential factors. We found that cognitive factors are one of the most influential factors in terms of predicting student interest in STEM careers and STEM discipline-specific careers. Thus, teachers should emphasize knowledge in mathematics and science by focusing on constructivist teaching and learning in mathematics and science (e.g., inquiry learning) to increase their motivation and achievement in these subjects. Teachers should also build a friendly and fun atmosphere in their science and mathematics classes. In addition, STEM teaching and learning should be incorporated to improve student interest in STEM careers. Other important factors include self-efficacy and outcome expectations. Thus, teachers should encourage learning activities that prioritize these factors by providing a comfortable teaching and learning environment in STEM classes. Finally, the theoretical models developed in this study is possible to be adapted for further cross-cultural studies because they were developed according to previous studies from different contexts.

Data availability

The datasets generated during and/or analyzed during the current study are available in the Mendeley data repository, <https://doi.org/10.17632/rzvfpm9kt.1>.

Received: 14 June 2024; Accepted: 21 January 2025;

Published online: 29 January 2025

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Author contributions

Ijtihadi Kamilia Amalina: Conceived and designed the study, collected, analyzed and interpreted the data, wrote the paper. Tibor Vidákovich: Supervised the study, analyzed and interpreted the data, validated the content of the paper. Könül Karimova: Analyzed and interpreted the data, wrote the paper.

Funding

The study was supported by a grant from the University of Szeged Open Access Fund with grant number 7375. Open access funding provided by University of Szeged.

Competing interests

The authors declare no competing interests.

Ethical approval

Approval was obtained from the Institutional Review Board of the University of Szeged, Hungary, under the ethical approval number 7/2022 (issued on 5 July, 2022). The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Informed consent

Written consent was obtained from parents or legal guardians of participating students.

Additional information

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