MODESTUM EURASIA Journal of Mathematics, Science and Technology Education, 2025, 21(2), em2584
ISSN:1305-8223 (online)
OPEN ACCESS Research Paper https://doi.org/10.29333/ejmste/15954

Unlocking Indonesian primary students' attitudes toward STEM education and interests in STEM-related careers using latent profile analysis

Marison Sudianto Manalu [1], Chun-Yen Chang [1,2,3*]

[1] Graduate Institute of Science Education, National Taiwan Normal University, Taipei, TAIWAN
[2] Institute for Research Excellence in Learning Sciences, National Taiwan Normal University, Taipei, TAIWAN
[3] Department of Biology, Universitas Negeri Malang, Malang, INDONESIA

Received 30 September 2024 ▪ Accepted 17 January 2025

Abstract

This study explores the attitudes of Indonesian primary students toward science, technology, engineering, and mathematics (STEM) education and their interest in STEM-related careers. We conducted a survey using the students' attitudes toward STEM (S-STEM) instrument, collecting data from 166 fourth and fifth-grade students (93 females and 73 males) in North Sumatra and West Java provinces, Indonesia. By employing latent profile analysis (LPA), we categorized student interest in STEM into three distinct groups: high, moderate, and low interest. Surprisingly, our findings indicate no significant differences in interest based on grade, gender, school location, or school type. The insights gained from LPA highlight the importance of customized educational strategies to promote effective STEM engagement in Indonesia. This research underscores the role of attitudinal profiling in enhancing STEM education implementation and nurturing future STEM careers.

Keywords: STEM education, attitudes toward STEM, interests, STEM-related careers, primary students, latent profile analysis

INTRODUCTION

Science, technology, engineering, and mathematics (STEM) education has benefits, such as a better understanding of technology and equipment (Bybee, 2010). STEM-educated students fields often demonstrate problem-solving skills, innovation, invention, self-reliance, logical reasoning, and proficiency in STEM literacy (Morrison, 2006). Therefore, candidates with a strong STEM background are in high demand from industries (Prinsley & Baranyai, 2015). Moreover, there is an increasing agreement that STEM education is essential for the economy, with business and industry groups stressing the need to enhance STEM skills to address future economic and social challenges (English, 2016; Hachey, 2020).

STEM interest appears at a young age (Maltese et al., 2014), and primary school students show a high interest in STEM subjects (Savelsbergh et al., 2016). However, students' interest in STEM generally remains relatively low (Chen, 2013), possibly due to the K-20 educational systems' inability to produce a sufficient number of STEM-capable students to fulfill the requirements for conventional STEM careers and alternative industries requiring similar skills (Carnevale et al., 2011). Moreover, primary students' interest toward STEM tends to decline as students move to higher education levels, especially among girls (Sadler et al., 2012; Sithole et al., 2017).

In Indonesia, researchers, teachers, and all the stakeholders in the science field have committed to STEM education, as can be seen from the international collaboration with United States Agency for International Development. Nugroho et al. (2019) examined the perceptions of Indonesian science teachers. They found that while science teachers understand the need for STEM education, there is still a need to raise awareness among the government, educators, and their institutions. Nuraeni et al. (2021) conducted a review study and discovered that numerous studies demonstrated a significant interest in creating STEM-based teaching and learning materials for elementary schools in Indonesia.

✉ 80945004s@ntnu.edu.tw ✉ changcy@ntnu.edu.tw **(*Correspondence)**

Contribution to the literature

- This study supports research on students' attitudes toward STEM and interests in STEM-related careers by utilizing latent profile analysis (LPA) to identify distinct groups based on their engagement with science, mathematics, engineering, and technology.
- It contributes to the existing literature by highlighting the lack of significant demographic differences in STEM interest across grade, gender, school location, and school type.
- The findings of the study contribute to the development of evaluation, reflection, and continuous improvement of STEM education in Indonesia, especially the need for targeted interventions to foster student interest in mathematics and other less popular STEM domains.

This study utilizes LPA to explore students' interest in STEM, a departure from traditional STEM survey research that has primarily focused on survey development, descriptive statistics such as mean and standard deviation, and group comparisons (e.g., Permanasari et al., 2021; Wakhid et al., 2021). LPA is a methodological approach employing a categorical latent variable framework to identify hidden subpopulations among a larger population based on certain variables. By leveraging LPA, this study categorizes students into distinct groups with varying probabilities, offering a nuanced understanding of STEM interest profiles (Gao et al., 2020; Krell et al., 2014). Furthermore, the STEM education research in Indonesia predominantly focused on middle to higher education levels, with relatively few studies investigating primary students' attitudes toward STEM and their interest in STEM-related careers. Particularly in Indonesia, where STEM education is still emerging, research is scarce at the primary education level (Farwati et al., 2021). This study provides insights into Indonesian primary students' STEM interest profiles, thereby contributing to the broader literature on STEM education and informing future educational policies and practices in Indonesia. To measure Indonesian primary students' interests in STEM, we used a Students Attitudes Toward STEM Survey (S-STEM) developed by the Friday Institute for Educational (2012). To guide this study, we proposed three research questions:

1. To what extent do primary school students engage with STEM education?
2. Are there any STEM profiles to be identified among the fourth and fifth graders of the population?
3. Are there any relationships between the STEM profile and students' demographics, such as gender, school location, school type, and grade level?

LITERATURE REVIEW

The Attitudes Toward STEM

Past research has extensively explored students' attitudes toward school subjects (Osborne et al., 2003; Toma & Greca, 2018). The word attitude refers to the degree of favorability and unfavourability as a response to a psychological object (Fishbein & Ajzen, 1977). Moreover, Ajzen and Cote (2008) postulated that positive and negative attitudes are not something a person acquires at birth. Unfortunately, the definition of attitudes toward STEM remains unclear (Altmann, 2008). According to her study, the importance of an attitude is "that it has a cognitive, affective, and behavioral component; it is bipolar; it is a response to a stimulus." Moreover, Pryor et al. (2016) define attitude as "positive, negative, or neutral feeling toward some object or behavior. Attitude can vary in strength and direction, from extremely favorable to extremely unfavorable, or any point in-between" (p. 126). Therefore, in this study, attitude indicates whether students have positive, negative, or neutral feelings toward STEM and interests in STEM-related careers.

Some studies regarding STEM attitudes and career interests in students' preferences for courses and careers, such as Wang (2013), showed that STEM attitudes are important for pursuing a career in STEM. Similarly, Blotnicky et al. (2018) investigated how STEM career knowledge, mathematics self-efficacy, career interests, and career-related activities are related to the probability of choosing a STEM career. They discovered that students possessing greater self-efficacy in mathematics and more knowledge about STEM careers tend to choose a STEM career. Likewise, Nugent et al. (2015) investigated students aged 10-14 who attended robotics camps as part of STEM education projects and found that early-age interest in STEM will be a powerful predictor of career outcome expectation. However, the review study by Li et al. (2020) revealed that most STEM education research is still produced from a small pool of countries, including the USA, Australia, Canada, and some Asian countries such as Taiwan and Turkey. Since STEM education is relatively new in Indonesia, this can be seen from STEM education trends that started in 2019 (Farwati et al., 2021). Thus, exploring students' attitudes toward STEM and career interests is important.

The Importance of Interests in STEM-Related Careers

Interests like reading are essential in teaching and learning (McDaniel et al., 2000). Educational research is primarily concerned with two categories of interest. First is situational interest, which may disappear over time and primarily focuses on the attention and affective reaction caused by surrounding stimuli (Hidi, 1990; Hidi & Baird, 1986). In this study, career interests are viewed as situational interests that arise from STEM education, influencing individuals' attention and responses. The second is individual interest; this interest stays longer than the situational interest, which involves the current psychological state. According to Hidi and Renninger (2006), there are four phases of the development and deepening of students' interests such as "triggered situational interest, maintained situational interest, emerging (less-developed) individual interest, and well-developed individual interest" (p. 111). Similarly, career interests have numerous definitions. The common factors from all the definitions are stated: "as a report or relationship between a subjective requirement and a given objective which can become interesting for the subject" (Popescu Neveanu, 1978, as cited in Vasilescu et al., 2015). The term "career interests" is often used for a person who wants to pursue a career with some career as their reference.

Creating curiosity in STEM among students is one of the goals of STEM education. By comparing males and females, Morgan et al. (2001) examined the function of interest in understanding profession choice and demonstrated that interest could predict students' career choices. Jacobs et al. (1998) found that young women's current interest strongly influences their science careers compared to GPA, their mathematics and science activities, and parents' perceptions. A prior study by Maltese et al. (2014) found that students' interest in STEM is broad. In addition, Mohd Shahali et al. (2016) assessed middle secondary students in nonformal integrated STEM education and found that effective pedagogical practices increase students' interest and motivation in STEM.

Moreover, Dabney et al. (2012) found that middle school students' interest in science and mathematics significantly influences their STEM career interests at the university level. Previous research has also shown a connection between science education and interest in STEM careers. Dorph et al. (2018) found that adolescents in science learning prefer a STEM career, including a specific career goal. Lower-education students originally do not know the careers they want to pursue. However, early-career aspiration can help students predict the STEM majors or careers they wish to pursue. For example, Cannady et al. (2014) found that academic STEM success can be predicted better than mathematics achievement using career expectations. Therefore, exploring more interest in STEM, particularly STEM-related careers, is important.

STEM Education in Indonesia

In Indonesia, STEM education is relatively new, and the implementation of STEM education started in 2014. Moreover, the research regarding STEM education in Indonesia is still very limited, with only 26 research studies conducted yearly (Farwati et al., 2021). Teachers act as the main facilitators in the teaching and learning process. The teachers are asked to serve multiple roles in STEM education, including the learner, designer, negotiator, collaborator, etc. (Slavit et al., 2016). However, from 2019 to 2020, the research trends in STEM education are considered significant (Farwati et al., 2021). In addition, they revealed that STEM education in Indonesia is intended to enhance students' skills, including 21st century skills, students' motivations toward learning, and enhance their entrepreneurial skills. However, compared to the number of schools, students, teachers, and researchers. The number of STEM research in Indonesia is quite small. Therefore, some other studies are needed to enhance the implementation of STEM education in Indonesia.

STEM Education Post-Pandemic COVID-19

The COVID-19 pandemic has profoundly impacted all sectors of human life, including health, economics, and education. In the education sector, it affected over 1.5 billion students globally (Chandra, 2021). The sudden shift to distance learning during the pandemic led to the widespread adoption of online platforms and virtual collaborative tools. This transition highlighted the importance of technological fields like data science, machine learning, and artificial intelligence, which played critical roles in combating COVID-19 (Alghamdi & Alghamdi, 2022). However, this abrupt change revealed challenges such as poor internet connectivity, and difficulties in classroom management (Gordy et al., 2021). Despite these challenges, the shift to online learning presented several opportunities, including prompted independent learning and student-centered learning allowing students to assess education remotely (Mukhtar et al., 2020; Nkwanyana & Fagbadebo, 2024).

Research suggests that the pandemic influenced student interest in STEM careers. For example, Alkhair et al. (2022) found that a computer-assisted STEM-based health awareness course increased pandemic awareness among high school students. The critical role of STEM during the pandemic such as in vaccine development and epidemiological modeling highlighted its societal significance. This visibility may positively influence students' perceptions of STEM careers, with many viewing them as essential to societal progress (Chen et al., 2024). The studies conducted in multiple countries indicates a rise in students' attitudes and interest toward STEM subjects and careers during the COVID-19 pandemic (Almukhambetova & Kuzhabekova, 2022; Anderson & Tully, 2020; Forakis et al., 2020; Wester et al., 2021). Therefore, in this study, we explore students' attitudes and interests toward STEM in Indonesia.

Overview of Latent Profile Analysis

LPA seeks to identify distinct groups or individual types based on their unique profiles of personal or environmental attributes. LPA can help in identifying constructed-based profiles, also referred to as classes, groups, or clusters in previous studies (Vermunt & Magidson, 2002; Wang & Hanges, 2010; Woo et al., 2018). LPA considers profile membership as an unobserved categorical variable, assigning individuals to profiles based on probabilities directly estimated from the model. This method provides several benefits. First, individuals are grouped into clusters according to estimated membership probabilities. Second, LPA can handle different types of variables continuous, categorical (nominal or ordinal) and counts. It includes demographics and other covariates to describe the profiles (Vermunt & Magidson, 2002).

Moreover, LPA focuses on finding patterns in variables, or LPA indicators, and groups people into profiles who exhibit similar patterns. The combinations of variables that create unique profiles and their relationships to predictors and results are then ascertained by comparing these profiles (Collins & Lanza, 2009; Wang & Hanges, 2010). In this study, LPA was used to investigate the differences in profile frequencies according to grade level, school type and location, and gender. Recently, research in education utilizing LPA has been increasing. For instance, Xu et al. (2022) employed LPA to categorize students to have better understanding self-regulation in mathematics homework. Similarly, Sui et al. (2024) explored high school students' scientific inquiry through animation-based activities, demonstrating the versatility of LPA in analyzing within science education contexts. Additionally, Cruz and Nagy (2024) applied LPA to examine the diverse pathways of women in STEM, highlighting its utility in understanding nuanced psychological and behavioral patterns. Furthermore, LPA is frequently applied in psychological research. For example, Wang et al. (2023) investigated the relationship between psychological flexibility and depression, anxiety, and stress among Chinese college students using LPA. These studies demonstrate that LPA is a robust tool for exploring and categorizing individual differences in various fields, providing valuable insights into student behavior, psychological traits, and pathways in STEM and beyond.

METHOD

In this study, we investigate Indonesian primary students' attitudes toward STEM and interests in STEM-related careers and describe the instrument, participants, and data analysis throughout this section.

Instrument

The survey used in the study was the student attitude toward science, technology, engineering, and mathematics (S-STEM) was a valid and reliable instrument developed by Friday Institute for Educational (2012) (**Appendix A**). The development and validation of the S-STEM survey were reported by Unfried et al. (2015). Cronbach's alpha of the overall survey with science, engineering, technology, and mathematics items was .83-.87. The original S-STEM survey was in English. This survey was conducted through construct and content validity, using exploratory factor analysis and subject matter experts has been reported in the original study Unfried et al. (2015). The S-STEM survey was translated into Indonesian (Bahasa) using the back-translation method and administered through Google Forms. The translation process involved two volunteer peers who contributed to ensuring the accuracy and reliability of the survey. First, the author translated the S-STEM survey from English to Indonesian. Then, a second translator independently translated the Indonesian version back into English. The author and both translators reviewed and discussed all survey items to confirm that the translations accurately conveyed the original meaning and were suitable for the Indonesian context. To ensure clarity, accuracy, and consistency, an expert in translation and interpretation was consulted. The expert reviewed all items, identified unclear sections, and recommended revisions, which were implemented. Subsequently, a pilot test was conducted with 20 students, and no difficulties were found in completing the survey. This comprehensive process ensured that the survey was linguistically and culturally appropriate for the target population. For the S-STEM survey Indonesian version, Cronbach's alpha of the overall survey with science, engineering, technology, and mathematics factors was .72-.94, all construct demonstrated a sufficient to high level of reliability.

In the S-STEM survey, four factors were measured separately:

(1) mathematics,

(2) science,

(3) engineering and technology, and

(4) interests in STEM-related careers.

The questions in the S-STEM survey used 5 points Likert scale ranging from 1 (strongly disagree), 2 (disagree), 3 (neither agree nor disagree), 4 (agree), and 5 (strongly agree), whereas for the career interests in STEM-related career used 4 points Likert scale ranging from 1 (not at all interested), 2 (not so interested), 3 (interested), and 4 (very interested). There are nine for science, eight items for mathematics, nine for engineering and technology, and 12 for career interests in STEM-related careers.

Table 1. Demographics of the study sample (n = 166)

Variable		Numbers
Grade	4th	83
	5th	83
School location	Urban	124
	Rural	42
Gender	Male	73
	Female	93
School type	Public	108
	Private	58

Participants

This study involved 166 fourth and fifth graders (93 females and 73 males) from three schools in two provinces in Indonesia: West Java and North Sumatra. The first two schools are private, one located in an urban area and the other in a rural setting, while the third is public and situated in an urban environment.

Three schools with different backgrounds were selected for this study to represent the Indonesian primary school population better. In Indonesia, West Java is the most populous province, with around 18% of the population, and Medan is the third most populated city in North Sumatra province. Additionally, **Table 1** summarizes the sample demographics. Furthermore, the students' participation was voluntary, consent forms were collected, clearly informing participants about the research purposes. Additionally, strict confidentiality was maintained throughout the data collection and analysis process. Participants were free to withdraw from the research at any stage, and their performance in the study would not affect their learning.

Latent Profile Analysis

First, we calculate the descriptive statistics in the first step to answer the first research question. We followed by LPA using tidy LPA (version 1.1.0) in the R platform (version 4.1.0). The tidy LPA package offers six distinct LPA Gaussian mixture models. Three different models are commonly used in the LPA; out of these two, Mplus software is required. One variance setting is termed "equal," which imposes constraints on variances across profiles, while the other, "varying," allows variances to be estimated without constraints.

Furthermore, the model is delineated by its configuration of variances and covariances. Additionally, there are three covariance settings: "zero," which does not estimate covariances; "equal," that computes covariances among indicators and imposes restriction across profiles; and "varying," that permits the free estimation of covariances (Rosenberg et al., 2018). In this study, we applied LPA with a varying number of groups, from 1 to 10, using a model with equal variance and zero covariance, as alternative models did not converge. Third, following the LPA, the profiles were generated and categorized as a categorical variable to investigate significant differences among groups of categorical variables. A Chi-square (χ^2) test and cross-tabulation analysis were performed to investigate the relationships and possible dependencies among the profiles ($p < .05$) (Agresti, 2012; White, 2004).

RESULT

This study explored students' attitudes toward STEM and interests in STEM-related careers. The findings in this section are presented in line with each research question.

Descriptive Statistics of the Primary Student Attitudes Toward STEM

Table 2 presents the descriptive statistics from the S-STEM survey on students' attitudes toward STEM subjects. The results indicate that students have a positive attitude toward science with a general affirmation that they do well in science and its future importance in careers. The mean score ranges from 2.99 to 3.40, indicating a moderate to high positive attitude; the standard deviation (SD) also range from 1.00 to 1.23, showing moderate variability in students' responses. On the other hand, mathematics shows more variability and anxiety toward mathematics as the evidence such as "Math is a difficult subject" (e.g., items M1, M3, and M5) these items show a higher means ranging from 3.14-3.55. In addition, the SD show moderate agreement among respondents (0.94-1.10). Furthermore, for engineering and technology, it seems that students show a positive inclination toward these factors, especially in creativity and its utility. The mean score for these factors ranges from 3.04 to 3.60, with a moderate variability in responses SD 1.03 to 1.18. Finally, the future interest in STEM careers points to a moderate level; however, there is a consistent response among students in this particular factor, with SD ranging from 0.77 to 0.94. We found that students are strongly interested in using science and mathematics to invent and improve things (57.49-69.46%). However, they are less likely to see the importance of designing products or structures or to express a strong interest in engineering (31.14-47.90%). While most students recognize the value of science in their future careers (49.10-52.10%), they are not as likely to see themselves pursuing a career in science (29.94-33.53%). Moreover, the survey found that many students struggle with mathematics and see it as challenging (41.51-61.68%).

Determining the STEM Interest Profile

In this section, we explore whether distinct profiles of STEM interest exist, using z-scores from science, technology, engineering, mathematics, and future. We employed LPA with a model configuration of equal variance and zero covariance, testing group solutions ranging from 1 to 10. To determine the best-fitting

Table 2. Descriptive statistics of students' attitudes toward STEM (n = 166)

Code	Mean	Standard deviation
S1	3.28	1.16
S2	3.02	1.00
S3	3.04	1.04
S4	3.28	1.23
S5	3.17	1.18
S6	3.05	1.04
S7	3.26	1.09
S8	3.40	1.01
S9	2.99	1.04
M1	3.55	1.01
M2	2.92	1.10
M3	3.32	1.04
M4	2.79	0.94
M5	3.14	1.13
M6	2.90	1.00
M7	3.17	0.98
M8	2.79	0.99
ET1	3.41	1.11
ET2	3.40	1.12
ET3	3.04	1.03
ET4	3.15	1.12
ET5	3.19	1.14
ET6	3.41	1.18
ET7	3.60	1.18
ET 8	3.46	1.17
ET9	3.32	1.15
FT1	2.58	0.77
FT2	2.70	0.94
FT3	2.75	0.89
FT4	2.54	0.88
FT5	2.53	0.83
FT6	2.62	0.89
FT7	2.68	0.86
FT8	2.69	0.85
FT9	2.65	0.91
FT10	2.47	0.88
FT11	2.54	0.92
FT12	2.68	0.89

Note. S: Science; M: Mathematic; ET: Engineering and technology; & FT: Future

model, we sequentially applied several criteria: the Akaike information criterion (AIC), Bayesian information criterion (BIC), the sample-adjusted BIC (sBIC), entropy, the bootstrapped likelihood ratio test (BLRT), as presented in **Table 3**.

We employed a comprehensive set of model selection techniques to determine the optimal model fit, started from the BIC, followed by sBIC, entropy, and the BLRT, finally checked the AIC which applied sequentially. The BIC helps avoid overfitting by balancing the complexity of the model with the size of the data set used. At the same time, the sBIC modifies the BIC to account for variations in sample sizes across models, with lower values suggesting a better fit. Entropy measures the distinctiveness of the latent classes; a high entropy value indicates clear, well-defined class separations, whereas low entropy suggests considerable overlap or ambiguity. The BLRT compares the fit of the model with one fewer class to determine if the additional class significantly improves the model.

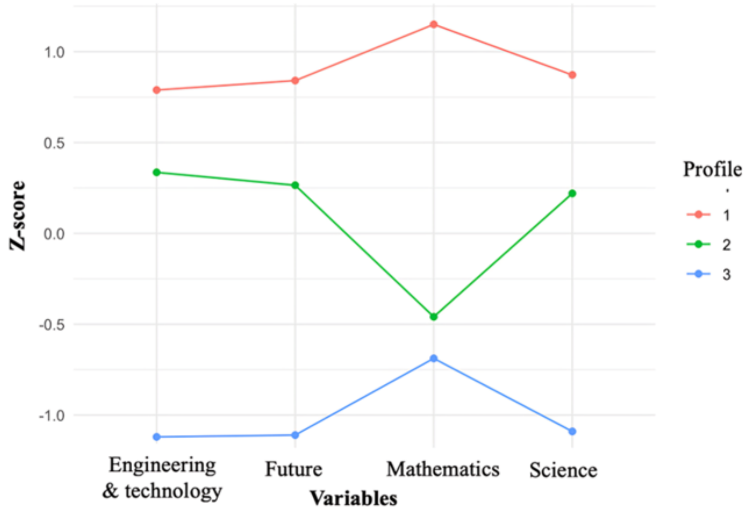
Table 3. Analysis of fit statistics for a decreasing number of groups

Numbers of group	1	2	3	4	5	6
Log-likelihood	-723	-596	-565	-553	-548	-539
Number of free parameters	8	17	26	35	44	53
AIC	1,463	1,218	1,165	1,152	1,151	1,145
BIC	1,488	1,258	1,221	1,223	1,239	1,247
sBIC	1,462	1,217	1,164	1,151	1,150	1,143
Entropy	1	0.959	0.834	0.811	0.598	0.609
BLRT (p)	N/A	N/A	<0.01	N/A	N/A	N/A
Smallest group frequency	100	94.4	83.4	81.1	59.8	60.9

Similarly, the AIC assesses model fit by weighing the goodness of fit against the complexity of the model, where lower values indicate a better fit. It is essential to note that no single fit index conclusively determines the best model; instead, combining these indices, alongside theoretical justifications and the practical interpretability of the classes, should guide model selection. This methodological approach is supported by studies such as those by Nylund et al. (2007) and Spurk et al. (2020), emphasizing the importance of a holistic assessment in model selection.

To find the best-fitting model, we systematically compared the fit indices of several models. The AIC, BIC, and SBIC for the three-group model are displayed in **Table 3**. We also considered p-values from the BLRT and entropy. In the two-group model, the entropy was greatest, indicating good group distinction. However, the significance could not be ascertained since the BLRT p-value for the two-group model was unavailable. In the end, the model that fit the data the best was the three-group profile solution. The Z-score for the chosen three-group profile solution for science, mathematics, engineering, technology, and the future is shown in **Figure 1**.

It showed significant differences in variances among the groups for the four indicators (science, mathematics, engineering and technology, and future) in the homogeneity of variances test. MANOVA was conducted to examine the effect of groups on multiple dependent variables. The MANOVA indicated a significant multivariate effect of group, V = 1.1522, F (8, 322) = 54.704, $p < .001$. ANOVA were performed for each dependent variable. For science, there was a significant effect of group, F(2, 163) = 144.11, $p < .001$, $\eta^2 = .6395$. Similarly, for mathematic, there was a significant effect of group, F(2, 163) = 83.986, $p < .001$, $\eta^2 = .5193$. For engineering and technology, group had a significant



Symbol	Profile	Science	Mathematics	Engineering & technology	Future
-	Profile 1 (n = 47, 28.31%)	0.87	1.15	0.79	0.84
-	Profile 2 (n= 89, 53.61%)	0.22	-0.46	0.33	0.26
-	Profile 3 (n= 30, 18.07%)	-1.09	-0.69	-1.12	-1.11

Figure 1. LPA of interest in STEM: Three profiles (Source: Authors' own elaboration)

Table 4. Distribution of profiles across demographic characteristics

Variable		Number (frequency) [residual]			Sum	χ^2 (p-value)
		High interest	Moderate interest	Low interest		
Grade	4th	25 (30.12%) [.3]	42 (50.60%) [-.4]	16 (19.28%) [.3]	83	.61 (.739)
	5th	22 (26.51%) [-.3]	47 (56.63%) [.4]	14 (16.87%) [-.3]	83	
School location	Urban	36 (29.03%) [.2]	67 (54.03%) [.1]	21 (16.94%) [-.3]	124	.46 (.796)
	Rural	11 (26.19%) [-.3]	22 (52.38%) [-.1]	9 (21.43%) [.5]	42	
Gender	Male	23 (31.51%) [.5]	38 (52.05%) [-.2]	12 (16.44%) [-.3]	73	.72 (.697)
	Female	24 (25.81%) [-.5]	51 (54.84%) [.2]	18 (19.35%) [.3]	93	
School type	Public	29 (26.85%) [-.3]	57 (52.78%) [-.1]	22 (20.37%) [.6]	108	1.18 (.555)
	Private	18 (31.03%) [.4]	32 (55.17%) [.2]	8 (13.79%) [-.8]	58	

Note. Residual is standardized person residual

effect, $F(2, 163) = 238.99$, $p < .001$, $\eta^2 = .7471$. Finally, for Future, group had a significant effect, $F(2, 163) = 69.869$, $p < .001$, $\eta^2 = .4614$. These results indicate that group significantly influences academic performance in science, mathematics, engineering and technology, and future expectations. Furthermore, the Bonferroni correction was applied to identify the differences among the three profiles. The analysis indicated significant differences between the "low interest in STEM," "moderate interest in STEM," and "high interest in STEM" groups. Significant differences were observed between the high interest and low interest groups, as well as between the high interest and moderate interest groups. However, no practical significance was found between the moderate interest and low interest groups.

To answer the second research question, we characterized the three profiles based on the LPA and MANOVA results. We named the first group "high interest in STEM," which is characterized by high scores in science, mathematics, engineering and technology, and future. The second group, characterized by moderate scores in these areas, was named "moderate interest in STEM." Lastly, the third group was called "low interest in STEM" due to its low scores in science, mathematics, engineering and technology, and future compared to the other two groups.

Distributions of Profiles Across the Demographic Characters

We employed the Chi-square test (χ^2) to explore the research question to examine the association between categorical variables (**Table 4**). Subsequent analysis included applying the Bonferroni correction to adjust for multiple comparisons and calculating standardized Pearson residuals to assess the magnitude and direction of deviations from expected frequencies. These steps were taken to ensure a robust examination of associations and mitigate the risk of type I error. There were no significant differences between all the variables in the follow-up test (**Figure 2**).

DISCUSSION

This study provides a foundational understanding of primary students' attitudes toward STEM subjects, encompassing science, mathematics, engineering, and

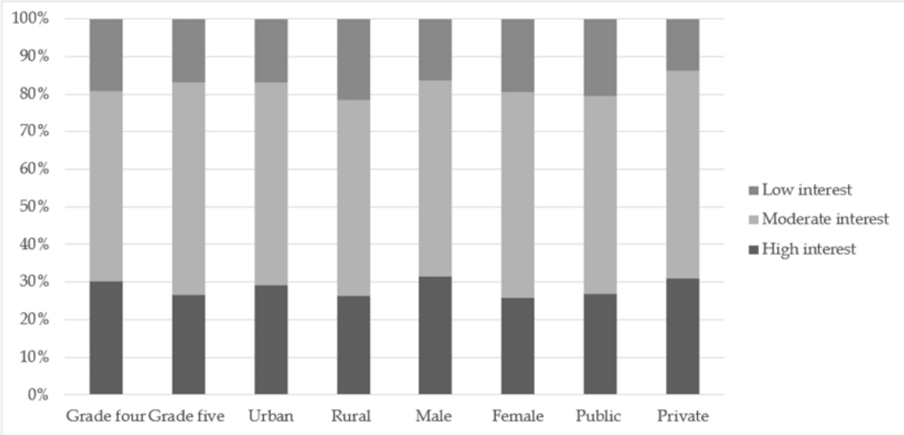


Figure 2. Percentage of profiles across demographic characteristics (Source: Authors' own elaboration)

technology, and their future interest in these fields. The following sections will discuss the research questions in detail and in a structured manner.

To What Extent Do Primary School Students Engage With STEM Education?

In addressing the first research question, we utilize descriptive statistics to examine students' STEM interests. The findings indicate a broad spectrum of interest levels across different STEM subjects. Students generally exhibit positive attitudes toward science, as reflected by the mean scores ranging from 2.62 to 3.33, indicating an overall favorable perception of science among primary students. This result is aligned with Astalini et al. (2019) during the evaluation of students' attitudes toward science in Indonesia, students' attitudes toward a career in science were categorized as sufficient. The result also indicated that students are highly interested in some science careers, such as physics and biology, but not chemistry-related careers; this finding reinforces the study from Ross et al. (2019) which conclude that compare to other science subject, students' has low involvement and interest toward chemistry due to their achievement in chemistry subject. This suggests that teaching science needs to enhance the strategies to be more appealing to the students, especially for chemistry.

In the other hand, the findings present a nuanced perspective on students' attitudes toward mathematics. While some students hold a positive outlook, others experience significant anxiety, as evidenced by the notably high mean score of 3.07 for "Math has been my worst subject," indicating widespread apprehension toward mathematics. The sentiments toward the subject are mixed: some students perceive it as challenging, whereas others feel confident in their ability to excel and achieve good grades. These results are in line with the study from Capinding (2022) which indicate that during the COVID-19 pandemic there is a high anxiety in mathematics among the students. Furthermore, in the higher education level, approximately around 70% of undergraduate students may experience a high level of mathematical anxiety in the near future (Amani et al., 2021). Despite these challenges, there is a demonstrated interest in mathematics-related careers among students, suggesting that enhanced educational strategies in teaching mathematics could be a viable approach to support those who struggle with the subject and foster interest in mathematics-related careers. The varied levels of comfort and anxiety highlight the necessity for targeted educational interventions aimed at boosting mathematical confidence and alleviating anxiety tailored to meet the diverse needs of students.

Similarly, in engineering and technology, students show a positive inclination toward engineering and technology, particularly valuing creativity and practical utility. The mean scores for these factors range from 3.33, highlighting a recognition of the value of engineering and technology skills, suggesting areas for deeper engagement and understanding in these subjects. On the other hand, the future career interest in STEM among primary students shows a moderate level of interest, with a mean score of 2.62, signifying that while there is some inclination toward pursuing STEM careers, there is also significant room for improvement. Encouraging students through positive experiences and effective STEM education could help increase their interest and confidence in considering STEM-related career paths. This result is aligned with (Perdana et al., 2021), which showed that Indonesian elementary students' attitudes toward engineering and technology are moderate, indicating that engineering and technology have the potential to bring about positive change in STEM education in Indonesia and inspire students to pursue careers in STEM fields as well. Moreover, the findings indicated that they were interested in pursuing careers in engineering or technology. Overall, the data indicate a generally positive attitude toward STEM, with notable differences in the levels of interest and anxiety across the subjects. These insights underline the importance of tailored educational strategies to foster confidence and interest in all STEM areas.

Are There Any STEM Profiles to Be Identified Among the Fourth and Fifth Graders of the Population?

LPA was conducted to identify students' distinct profiles of STEM interest and address the second research question. These profiles varied across science, mathematics, engineering, technology, and future career interests. The analysis identified three distinct profiles (**Figure 1**): high interest (n = 47, 28.31%), moderate interest (n = 89, 53.61%), and low interest in STEM (n = 30, 18.07%).

Profile 1 (high interest in STEM) is characterized by students demonstrating robust engagement and positive responses across all STEM domains. Their standardized scores (z-scores) range from 0.79 in engineering and technology to 1.15 in mathematics, the highest score across all domains. They highlight a strong inclination toward mathematics within this group, underscoring a favorable attitude toward the subject compared to their peers in other profiles. The overall positive stance of Profile 1 students is likely to shape their perception of STEM fields as viable and appealing career paths. This enthusiasm is crucial as it enhances student confidence in tackling complex problems and fosters a deeper understanding of scientific principles. Students in this profile will likely be receptive to advanced STEM-related educational opportunities and enrichment activities, which can further solidify their interest and proficiency.

Additionally, their robust engagement suggests they could serve as peer motivators, inspiring classmates with reservations about STEM subjects. Moreover, their strong performance in mathematics, a foundational subject for all other STEM fields, may facilitate success in specialized areas like physics or computer science. This positive feedback loop of interest and achievement creates an ideal environment for nurturing future innovators and leaders in STEM disciplines. These findings are align with some recent studies which show that primary students shows a high interest in STEM (Chen et al., 2022; Luo et al., 2021; Zhou et al., 2019).

Profile 2 (moderate interest in STEM) represents the majority of the student population, exhibits a balanced, albeit more cautious, interest in STEM. Students in this group show moderate enthusiasm with z-scores of 0.22 in science and 0.33 in engineering and technology but demonstrate a negative perception in mathematics (-0.46), indicating a dichotomy within the group, with a higher interest in hands-on and application-based fields like engineering compared to theoretical domains such as mathematics. The varied responses within profile 2 suggest a need for differentiated instructional strategies that can bolster interest, particularly in mathematics.

Profile 3 (low interest in STEM) is characterized by a low interest in STEM, displays the least interest across all domains: science (-1.09), mathematics (-0.69), engineering and technology (-1.12), and future career (-1.11). These scores indicate a pervasive disinterest or potential anxiety related to STEM, potentially influenced by negative past experiences or a lack of exposure to inspiring STEM education. Targeted interventions are necessary to enhance engagement and alter perceptions about STEM among students in profile 3. These results align with earlier studies (e.g., Farida et al., 2022; Suprapto, 2016), highlighting students' varying interest levels in STEM education. They indicate that while most students show interest in STEM, there is a significant variation in the intensity of Indonesian students.

The distribution of these profiles provides valuable insights into the varied levels of interest and engagement among students at critical stages in their education. It highlights the importance of tailored educational approaches to cultivating a robust interest in STEM, particularly for those with moderate or low existing interest. Future research should explore the underlying causes of this distribution and each profile's specific needs to address STEM education gaps effectively. Further, it is crucial to investigate how these interests develop over time and the role of educators in shaping these attitudes. Practical implications for both moderate and low interest profiles could include initiatives like STEM-focused project-based learning, where students engage in collaborative, real-world problem-solving tasks. These projects could span diverse topics, such as designing simple engineering models, conducting science experiments, or developing basic coding applications, to cultivate curiosity and skills in STEM fields. Additionally, gamified learning platforms that incorporate adaptive challenges and interactive problem-solving scenarios could make STEM subjects more engaging and less intimidating for these students.

Are There Any Relationships Between the STEM Profile and Students' Demographics, Such as Gender, School Location, School Type, and Grade Level?

In addressing the third research question, we utilized the Chi-square (χ^2) test to investigate differences in STEM interest profiles across various demographic variables (**Table 4**). The findings indicate that the distribution of interest levels remains relatively consistent across grades, locations, genders, and school types, suggesting that intrinsic factors such as individual predispositions or extracurricular exposure to STEM may play a more critical role in shaping students' interests than the demographic variables examined, as none of the demographic variables showed significance (**Figure 2**).

The analysis further revealed that both fourth and fifth graders displayed similar distribution patterns in their interest levels. Approximately 26.51-30.12% of students in both grades demonstrated high interest in STEM, around 16.87-19.28% showed low interest, and the majority, approximately 50.60-56.63%, exhibited moderate interest. This consistent engagement with STEM subjects as students progresses through these formative educational years highlights a sustained interest in STEM education.

The data indicated negligible differences when comparing interest in STEM between urban and rural school locations. In both contexts, roughly 26.19-29.03% of students reported having high interest, 52.05-52.38% reported having moderate interest, and 16.94-21.43% reported having low interest. These findings suggest that school location, whether urban or rural, does not significantly influence students' levels of interest in STEM. These findings contrast with earlier studies (e.g., Avery, 2013; Saw & Agger, 2021; Starrett et al., 2022) which may indicate shifts in educational and societal influences over time.

The gender analysis revealed comparable interest levels in STEM among male and female students, with high interest reported by 25.81-31.51% of students across both genders. These finding challenges common stereotypes about gender disparities in STEM fields and supports the notion that males and females are equally capable of and interested in STEM subjects. These results contrast with previous research (Chan, 2022; Kiernan et al., 2022; McMaster et al., 2023), which suggests a gap between female and male students in STEM. This finding underscores the evolving landscape of STEM education and the changing perceptions and opportunities available to students of all genders. It suggests that efforts to encourage and support STEM interest among students should be inclusive and equitable, irrespective of gender. Furthermore, comparing public and private schools showed no significant variation in interest levels. In both educational settings, 26.85-31.03% of the students expressed high interest in STEM, 52.78-55.17% had moderate interest, and 13.79-20.37% demonstrated low interest. This similarity suggests that the type of school might not be as influential in determining students' interest in STEM as the quality of STEM education provided. However, it is important to recognize that the findings of this study might be biased by its focus on specific grades and a quite limited sample size, which restricts the applicability of the results. These findings are in line with (Çevik & Özgünay, 2018; Killpack & Melón, 2016). Future studies should consider a broader range of grades and a larger sample size to understand better the dynamics of STEM interest across different demographic segments and enhance the findings' robustness. Finally, we suggest introducing more STEM activities at an early age which can help to sustain and develop their attitudes and interest toward STEM and STEM careers in the future. STEM education content such as showcasing real-world applications of STEM for example collaborating with industry professionals or STEM career fairs may inspire students to envision future opportunities in STEM. As for the Indonesian context, more teacher training for curriculum development and STEM projects should reflect the diverse interests and capabilities of student populations. For future research, longitudinal studies could examine how these profiles evolve and the long-term impact of targeted interventions on students' academic trajectories and career choices in STEM fields.

CONCLUSION AND LIMITATIONS

This study aimed to investigate students' attitudes and interest in STEM through students' demographic factors with the STEM profile. Using descriptive statistics and LPA, the study identified three distinct STEM interest profiles among fourth and fifth-grade students: high interest (28.31%), moderate interest (53.61%), and low interest (18.07%) in STEM. High interest students demonstrated robust engagement across all STEM domains, particularly excelling in mathematics, highlighting their favorable attitudes toward this subject compared to their peers. In contrast, moderate interest students showed a balanced but cautious interest in STEM, with a notable reservation in mathematics, indicating a need for differentiated instructional strategies to bolster interest in theoretical STEM subjects. Low interest students exhibited the least interest across all STEM domains. The findings also explored the relationships between STEM interest profiles and demographic variables such as grade level, school location, gender, and school type. We found that students' STEM interest profiles were not substantially influenced by these demographic factors. These results highlight the value of individualized teaching approaches to encourage positive STEM attitudes in a range of student demographics and provide guidance for future studies and policy initiatives aimed at fostering STEM engagement and encouraging students to pursue STEM-related occupations.

Finally, while this study provides valuable insights, there are some limitations that follow. First, we acknowledge that while the sample size of the study is sufficient for statistical analysis, it may not fully represent the diverse demographics of all Indonesian primary schools. Regional variations and socioeconomic differences can significantly influence students' attitudes toward STEM subjects, potentially limiting the generalizability of our findings. Second, limited focus on students in fourth and fifth graders limits the generalizability of the findings. Extending to other education levels would provide a more comprehensive understanding of STEM attitudes and interest across educational stages. Finally, while the study explored demographic factors, it did not examine other potential variables that may affect the students' attitudes and interest toward STEM. Such as parental education, economic level, access to technology, and intrinsic factors. Future research needs to consider this variable to provide more understanding of what factors drive more students' attitudes and interest toward STEM.

Author contributions: MSM & C-YC: writing–review and editing; **MSM:** conceptualization, methodology, formal analysis and investigation, and writing–original draft preparation; & **C-YC:** funding acquisition, resources, and supervision. Both authors agreed with the results and conclusions.

Funding: This study was financially supported by the "Institute for Research Excellence in Learning Sciences" of National Taiwan Normal University from The Featured Areas Research Center Program within the framework of the Higher Education Sprout Project by the Ministry of Education in Taiwan.

Ethical statement: The authors stated that this research did not involve any clinical investigations on humans or animals and was both risk-free and harmless. Consent forms were collected, clearly informing participants about the research purposes. Participation was voluntary and anonymous. The authors further stated that participants were free to withdraw from the research at any stage, and their performance in the study would not affect their learning.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

Agresti, A. (2012). *Categorical data analysis* (Vol. 792). John Wiley & Sons. https://doi.org/10.1002/0471249688

Ajzen, I., & Cote, N. G. (2008). Attitudes and the prediction of behavior. *Attitudes and Attitude Change, 13*, 289-311.

Alghamdi, N. S., & Alghamdi, S. M. (2022). The role of digital technology in curbing COVID-19. *International Journal of Environmental Research and Public Health, 19*(14). Article 8287 https://doi.org/10.3390/ijerph19148287

Alkhair, S., Ali, R., Elhawary, E., Al-Ejji, M., Ahmad, Z., Al-Thani, N., & Bhadra, J. (2022). Cultivating STEM interest in high school students through computer-assisted COVID-19 pandemic awareness course. *Educational Innovations and Emerging Technologies, 2*. https://doi.org/10.35745/eiet2022v02.02.0003

Almukhambetova, A., & Kuzhabekova, A. (2022). COVID-19 and the changes in STEM students' intentions to pursue international mobility. What do the students say? *European Education, 54*(1-2), 47-62. https://doi.org/10.1080/10564934.2022.2072748

Altmann, T. K. (2008). Attitude: A concept analysis. *Nursing Forum, 43*(3), 144-150. https://doi.org/10.1111/j.1744-6198.2008.00106.x

Amani, A., Alamolhodaei, H., Ghanbari, R., & Radmehr, F. (2020). An epidemiological model for predicting students' mathematics anxiety. *Journal of Interdisciplinary Mathematics, 24*(4), 793-805. https://doi.org/10.1080/09720502.2020.1786938

Anderson, J., & Tully, D. (2020). Designing and evaluating an integrated STEM professional development program for secondary and primary school teachers in Australia. In J. Anderson & Y. Li (Eds.), *Integrated approaches to STEM education* (pp. 403-425). Springer. https://doi.org/10.1007/978-3-030-52229-2_22

Astalini, A., Kurniawan, D., Kurniawan, N., & Anggraini, L. (2019). Evaluation of student's attitude toward science in Indonesia. *Open Journal for Educational Research, 3*, 1-12. https://doi.org/10.32591/coas.ojer.0301.01001a

Avery, L. M. (2013). Rural science education: Valuing local knowledge. *Theory Into Practice, 52*(1), 28-35. https://doi.org/10.1080/07351690.2013.743769

Blotnicky, K. A., Franz-Odendaal, T., French, Blotnicky, K. A., Franz-Odendaal, T., French, F., & Joy, P. (2018). A study of the correlation between STEM career knowledge, mathematics self-efficacy, career interests, and career activities on the likelihood of pursuing a STEM career among middle school students. *International Journal of STEM Education, 5*(1), Article 22. https://doi.org/10.1186/s40594-018-0118-3

Bybee, R. W. (2010). What is STEM education? *Science, 329*(5995), 996-996. https://doi.org/10.1126/science.1194998

Cannady, M. A., Greenwald, E., & Harris, K. N. (2014). Problematizing the STEM pipeline metaphor: Is the STEM pipeline metaphor serving our students and the STEM workforce? *Science Education, 98*(3), 443-460. https://doi.org/10.1002/sce.21108

Capinding, A. T. (2022). Impact of modular distance learning on high school students mathematics motivation, interest/attitude, anxiety and achievement during the COVID-19 pandemic. *European Journal of Educational Research, 11*(2), 917-934. https://doi.org/10.12973/eu-jer.11.2.917

Carnevale, A. P., Smith, N., & Melton, M. (2011). *STEM: Science, Technology, Engineering, Mathematics. Georgetown University Center on Education and the Workforce*. Washington, DC. https://cew.georgetown.edu/wp-content/uploads/2014/11/stem-complete.pdf

Çevik, M., & Özgünay, E. (2018). STEM education through the perspectives of secondary schools' teachers and school administrators in Turkey. *Asian Journal of Education and Training, 4*, 91-101. https://doi.org/10.20448/journal.522.2018.42.91.101

Chan, R. C. H. (2022). A social cognitive perspective on gender disparities in self-efficacy, interest, and aspirations in science, technology, engineering, and mathematics (STEM): The influence of cultural and gender norms. *International Journal of STEM Education, 9*(1), Article 37. https://doi.org/10.1186/s40594-022-00352-0

Collins, L. M., & Lanza, S. T. (2009). *Latent class and latent transition analysis: With applications in the social,* *behavioral, and health sciences* (Vol. 718). John Wiley & Sons. https://doi.org/10.1002/9780470567333

Cruz, M., & Nagy, N. (2024). Profiles in persistence: A latent profile analysis of multilevel coping strategies enacted among women in the sciences. *Journal of Organizational Behavior, 45*(3), 362-381. https://doi.org/https://doi.org/10.1002/job.2657

Dabney, K. P., Tai, R. H., Almarode, J. T., Miller-Friedmann, J. L., Sonnert, G., Sadler, P. M., & Hazari, Z. (2012). Out-of-school time science activities and their association with career interest in STEM. *International Journal of Science Education, Part B: Communication and Public Engagement, 2*(1), 63-79. https://doi.org/10.1080/21548455.2011.629455

Dorph, R., Bathgate, M. E., Schunn, C. D., & Cannady, M. A. (2018). When I grow up: The relationship of science learning activation to STEM career preferences. *International Journal of Science Education, 40*(9), 1034-1057. https://doi.org/10.1080/09500693.2017.1360532

English, L. D. (2016). STEM education K-12: Perspective on integration. *International Journal of STEM Education, 3*(1), 3. https://doi.org/10.1186/s40594-016-0036-1

Farida, F., Supriadi, N., Andriani, S., Pratiwi, D. D., Suherman, S., & Muhammad, R. R. (2022). STEM approach and computer science impact the metaphorical thinking of Indonesian students'. *Revista de Educación a Distancia (RED), 22*(69). https://doi.org/10.6018/red.493721

Farwati, R., Metafisika, K., Sari, I., Sitinjak, D. S., Solikha, D. F., & Solfarina, S. (2021). STEM education implementation in Indonesia: A scoping review. *International Journal of STEM Education for Sustainability, 1*(1), 11-32. https://doi.org/10.53889/ijses.v1i1.2

Fishbein, M., & Ajzen, I. (1977). Belief, attitude, intention, and behavior: An introduction to theory and research. *Philosophy and Rhetoric, 10*(2).

Forakis, J., March, J. L., & Erdmann, M. (2020). The impact of COVID-19 on the academic plans and career intentions of future STEM professionals. *Journal of Chemical Education, 97*(9), 3336-3340. https://doi.org/10.1021/acs.jchemed.0c00646

Friday Institute for Educational. (2012). Student attitudes toward STEM survey-upper elementary school students. *Friday Institute for Educational*.

Gao, Y., Zhai, X., Andersson, B., Zeng, P., & Xin, T. (2020). Developing a learning progression of buoyancy to model conceptual change: A latent class and rule space model analysis. *Research in Science Education, 50*(4), 1369-1388. https://doi.org/10.1007/s11165-018-9736-5

Gordy, X. Z., Sparkmon, W., Imeri, H., Notebaert, A., Barnard, M., Compretta, C., Dehon, E., Taylor, J., Stray, S., Sullivan, D., & Rockhold, R. W. (2021). Science teaching excites medical interest: A qualitative inquiry of science education during the 2020 COVID-19 pandemic. *Education Sciences, 11*(4). https://doi.org/10.3390/educsci11040148

Hachey, A. C. (2020). Success for all: Fostering early childhood STEM identity. *Journal of Research in Innovative Teaching & Learning, ahead-of-p*. https://doi.org/10.1108/JRIT-01-2020-0001

Hidi, S. (1990). Interest and its contribution as a mental resource for learning. *Review of Educational Research, 60*(4), 549-571. https://doi.org/10.3102/00346543060004549

Hidi, S., & Baird, W. (1986). Interestingness—a neglected variable in discourse processing. *Cognitive Science, 10*(2), 179-194. https://doi.org/10.1207/s15516709cog1002_3

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. Educational Psychologist, 41(2), 111-127.

Jacobs, J. E., Finken, L. L., Griffin, N. L., & Wright, J. D. (1998). The career plans of science-talented rural adolescent girls. *American Educational Research Journal, 35*(4), 681-704. https://doi.org/10.3102/00028312035004681

Kiernan, L., Walsh, M., & White, E. (2022). Gender in technology, engineering and design: Factors which influence low STEM subject uptake among females at third level. *International Journal of Technology and Design Education, 33*, 497-520. https://doi.org/10.1007/s10798-022-09738-1

Killpack, T. L., & Melón, L. C. (2016). Toward inclusive STEM classrooms: What personal role do faculty play? *CBE Life Sciences Education, 15*(3), Article es3. https://doi.org/10.1187/cbe.16-01-0020

Krell, M., Upmeier zu Belzen, A., & Krüger, D. (2014). Students' levels of understanding models and modelling in biology: Global or aspect-dependent? *Research in Science Education, 44*(1), 109-132. https://doi.org/10.1007/s11165-013-9365-y

Li, Y., Wang, K., Xiao, Y., & Froyd, J. E. (2020). Research and trends in STEM education: A systematic review of journal publications. *International Journal of STEM Education, 7*(1), 1-16. https://doi.org/10.1186/s40594-020-00207-6

Luo, T., So, W. W. M., Wan, Z. H., & Li, W. C. (2021). STEM stereotypes predict students' STEM career interest via self-efficacy and outcome expectations. *International Journal of STEM Education, 8*(1), Article 36. https://doi.org/10.1186/s40594-021-00295-y

Maltese, A. V., Melki, C. S., & Wiebke, H. L. (2014). The nature of experiences responsible for the generation and maintenance of interest in STEM. *Science Education, 98*(6), 937-962. https://doi.org/10.1002/sce.21132

McDaniel, M. A., Waddill, P. J., Finstad, K., & Bourg, T. (2000). The effects of text-based interest on attention and recall. *Journal of Educational Psychology, 92*(3), 492-502. https://doi.org/10.1037/0022-0663.92.3.492

McMaster, N., Carey, M., Martin, D., & Martin, J. (2023). Raising primary school boys' and girls' awareness and interest in STEM-related activities, subjects, and careers: An exploratory case study. *Journal of New Approaches in Educational Research, 12*, 1-18. https://doi.org/10.7821/naer.2023.1.1135

Mohd Shahali, E. H., Halim, L., Rasul, M. S., Osman, K., & Zulkifeli, M. A. (2016). STEM learning through engineering design: Impact on middle secondary students' interest towards STEM. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(5), 1189-1211. https://doi.org/10.12973/eurasia.2017.00667a

Morgan, C., Isaac, J. D., & Sansone, C. (2001). The role of interest in understanding the career choices of female and male college students. *Sex Roles, 44*(5), 295-320. https://doi.org/10.1023/A:1010929600004

Morrison, J. (2006). *Attributes of STEM education: The student, the school, the classroom*. Teaching Institute for Excellence in STEM. http://www.leadingpbl.org/f/Jans pdf Attributes_of_STEM_Education-1.pdf

Mukhtar, K., Javed, K., Arooj, M., & Sethi, A. (2020). Advantages, limitations and recommendations for online learning during COVID-19 pandemic era. *Pakistan Journal of Medical Sciences, 36*(COVID19-S4), S27-S31. https://doi.org/10.12669/pjms.36.COVID19-S4.2785

Nkwanyana, N. N., & Fagbadebo, O. (2024). The benefits of the use of online learning during the COVID-19 pandemic. *Journal of Infrastructure, Policy and Development. 8*(14), Article 9448. https://doi.org/10.24294/jipd9448

Nugent, G., Barker, B., Welch, G., Grandgenett, N., Wu, C., & Nelson, C. (2015). A model of factors contributing to STEM learning and career orientation. *International Journal of Science Education, 37*(7), 1067-1088. https://doi.org/10.1080/09500693.2015.1017863

Nugroho, O. F., Permanasari, A., & Firman, H. (2019). The movement of STEM education in Indonesia: Science teachers' perspectives. *Jurnal Pendidikan IPA Indonesia, 8*(3), 417-425. https://doi.org/10.15294/jpii.v8i3.19252

Nuraeni, F., Malagola, Y., Pratomo, S., & Putri, H. E. (2021). Trends of science technology engineering mathematics (STEM)-based learning at elementary school in Indonesia. *Premiere Educandum: Jurnal Pendidikan Dasar dan Pembelajaran, 11*(1), 87-103. https://doi.org/10.25273/pe.v11i1.8805

Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling: A Multidisciplinary Journal, 14*(4), 535-569. https://doi.org/10.1080/10705510701575396

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049-1079. https://doi.org/10.1080/0950069032000032199

Perdana, R., Apriani, A.-N., Richardo, R., Rochaendi, E., & Kusuma, C. (2021). Elementary students' attitudes towards STEM and 21st-century skills. *International Journal of Evaluation and Research in Education, 10*(3), 1080-1088. https://doi.org/10.11591/ijere.v10i3.21389

Permanasari, A., Rubini, B., & Nugroho, O. (2021). STEM education in Indonesia: Science teachers' and students' perspectives. *Journal of Innovation in Educational and Cultural Research, 2*, 7-16. https://doi.org/10.46843/jiecr.v2i1.24

Prinsley, R., & Baranyai, K. (2015). STEM skills in the workforce: What do employers want ? *Office of the Chief Scientist, Government of Australia, Occasional Paper Series, 9*, 1-4. https://doi.org/10.13140/RG.2.2.12120.60167

Pryor, B. W., Pryor, C. R., & Kang, R. (2016). Teachers' thoughts on integrating STEM into social studies instruction: Beliefs, attitudes, and behavioral decisions. *The Journal of Social Studies Research, 40*(2), 123-136. https://doi.org/10.1016/j.jssr.2015.06.005

Rosenberg, J., Beymer, P., Anderson, D., & Schmidt, J. (2018). tidyLPA: An R Package to easily carry out latent profile analysis (LPA) using open-source or commercial software. *Journal of Open Source Software, 3*(30), Article 978. https://doi.org/10.21105/joss.00978

Ross, J., Guerra, E., & Gonzalez-Ramos, S. (2019). Linking a hierarchy of attitude effect to student engagement and chemistry achievement. *Chemistry Education Research and Practice, 21*, 357-370. https://doi.org/10.1039/C9RP00171A

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education, 96*(3), 411-427. https://doi.org/10.1002/sce.21007

Savelsbergh, E. R., Prins, G. T., Rietbergen, C., Fechner, S., Vaessen, B. E., Draijer, J. M., & Bakker, A. (2016). Effects of innovative science and mathematics teaching on student attitudes and achievement: A meta-analytic study. *Educational Research Review, 19*, 158-172. https://doi.org/10.1016/j.edurev.2016.07.003

Saw, G. K., & Agger, C. A. (2021). STEM pathways of rural and small-town students: Opportunities to learn, aspirations, preparation, and college enrollment. *Educational Researcher, 50*(9), 595-606. https://doi.org/10.3102/0013189X211027528

Sithole, A., Chiyaka, E. T., McCarthy, P., Mupinga, D. M., Bucklein, B. K., & Kibirige, J. S. (2017). Student attraction, persistence and retention in STEM programs: Successes and continuing challenges. *Higher Education Studies, 7*, 46-59. https://doi.org/10.5539/hes.v7n1p46

Slavit, D., Nelson, T. H., & Lesseig, K. (2016). The teachers' role in developing, opening, and nurturing an inclusive STEM-focused school. *International Journal of STEM Education, 3*(1), Article 7. https://doi.org/10.1186/s40594-016-0040-5

Spurk, D., Hirschi, A., Wang, M., Valero, D., & Kauffeld, S. (2020). Latent profile analysis: A review and "how to" guide of its application within vocational behavior research. *Journal of Vocational Behavior, 120*, Article 103445. https://doi.org/10.1016/j.jvb.2020.103445

Starrett, A., Irvin, M. J., Lotter, C., & Yow, J. A. (2022). Understanding the relationship of science and mathematics place-based workforce development on adolescents' motivation and rural aspirations. *American Educational Research Journal, 59*(6), 1090-1121. https://doi.org/10.3102/00028312221099009

Sui, C.-J., Hsiao, S.-Y., Yeh, S.-C., Zhao, P., Chang, C.-Y., & Lin, J. (2024). Do they have inquiry skill profiles? Exploring high school students' scientific inquiry in an animation-based activity. *Science Education, 108*(2), 467-494. https://doi.org/10.1002/sce.21844

Suprapto, N. (2016). Students' attitudes towards STEM education: Voices from Indonesian junior high schools. *Journal of Turkish Science Education, 13*(Specialissue), 75-87. https://doi.org/10.12973/tused.10172a

Toma, R. B., & Greca, I. M. (2018). The effect of integrative STEM instruction on elementary students' attitudes toward science attitudes toward science. *Eurasia Journal of Mathematics, Science and Technology Education, 14*(4), 1383-1395. https://doi.org/10.29333/ejmste/83676

Unfried, A., Faber, M., Stanhope, D. S., & Wiebe, E. (2015). The development and validation of a measure of student attitudes toward science, technology, engineering, and math (S-STEM). *Journal of Psychoeducational Assessment, 33*(7), 622-639. https://doi.org/10.1177/0734282915571160

Vasilescu, C. C., Moraru, A., & Sava, N. I. (2015). The relationship between career interests and academic major: A comparative analysis. *Procedia-Social and Behavioral Sciences, 187*, 559-564. https://doi.org/10.1016/j.sbspro.2015.03.104

Vermunt, J. K., & Magidson, J. (2002). Latent class cluster analysis. In J. A. Hagenaars & A. L. McCutcheon (Eds.), *Applied latent class analysis* (pp. 89-106). Cambridge University Press. https://doi.org/10.1017/CBO9780511499531.004

Wakhid, M. U., Suhartini, S., & Nuraini, N. (2021). Analysis of the potential use of STEM approach in biology lessons refers to development of science in Indonesia. *Proceedings of the 6th International Seminar on Science Education (ISSE 2020)*. https://doi.org/10.2991/assehr.k.210326.017

Wang, J., Fang, S., Yang, C., Tang, X., Zhu, L., & Nie, Y. (2023). The relationship between psychological flexibility and depression, anxiety and stress: A latent profile analysis. *Psychology Research and Behavior Management, 16*, 997-1007. https://doi.org/10.2147/PRBM.S400757

Wang, M., & Hanges, P. J. (2010). Latent class procedures: Applications to organizational research. *Organizational Research Methods, 14*(1), 24-31. https://doi.org/10.1177/1094428110383988

Wang, X. (2013). Why students choose STEM majors: Motivation, high school learning, and postsecondary context of support. *American Educational Research Journal, 50*(5), 1081-1121. https://doi.org/10.3102/0002831213488622

Wester, E. R., Walsh, L. L., Arango-Caro, S., & Callis-Duehl, K. L. (2021). Student engagement declines in STEM undergraduates during COVID-19–driven remote learning. *Journal of Microbiology & Biology Education, 22*(1). https://doi.org/10.1128/jmbe.v22i1.2385

White, D. R. (2004). A Student's guide to statistics for analysis of cross-tabulations. *World Cultures, 14*.

Woo, S. E., Jebb, A. T., Tay, L., & Parrigon, S. (2018). Putting the "person" in the center: Review and synthesis of person-centered approaches and methods in organizational science. *Organizational Research Methods, 21*(4), 814-845. https://doi.org/10.1177/1094428117752467

Xu, J., Wang, C., Du, J., & Núñez, J. C. (2022). Profiles of student-perceived teacher homework involvement, and their associations with homework behavior and mathematics achievement: A person-centered approach. *Learning and Individual Differences, 96*, Article 102159. https://doi.org/10.1016/j.lindif.2022.102159

Zhou, S.-N., Zeng, H., Xu, S.-R., Chen, L.-C., & Xiao, H. (2019). Exploring changes in primary students' attitudes towards Science, Technology, Engineering and Mathematics (STEM) across genders and grade levels. *Journal of Baltic Science Education, 18*, 466-480. https://doi.org/10.33225/jbse/19.18.466

APPENDIX A: S-STEM SURVEY

Table A1. Student attitudes toward STEM survey

	SD	D	NAD	A	SA
Math	○	○	○	○	○
Math has been my worst subject.	○	○	○	○	○
When I'm older, I might choose a job that uses math.	○	○	○	○	○
Math is hard for me.	○	○	○	○	○
I am the type of student who does well in math.	○	○	○	○	○
I can understand most subjects easily, but math is difficult for me.	○	○	○	○	○
In the future, I could do harder math problems.	○	○	○	○	○
I can get good grades in math.	○	○	○	○	○
I am good at math.	○	○	○	○	○
Science	○	○	○	○	○
I feel good about myself when I do science.	○	○	○	○	○
I might choose a career in science.	○	○	○	○	○
After I finish high school, I will use science often.	○	○	○	○	○
When I am older, knowing science will help me earn money.	○	○	○	○	○
When I am older, I will need to understand science for my job.	○	○	○	○	○
I know I can do well in science.	○	○	○	○	○
Science will be important to me in my future career.	○	○	○	○	○
I can understand most subjects easily, but science is hard for me to understand.	○	○	○	○	○
In the future, I could do harder science work.	○	○	○	○	○
Engineering and technology	○	○	○	○	○
I like to imagine making new products.	○	○	○	○	○
If I learn engineering, then I can improve things that people use every day.	○	○	○	○	○
I am good at building or fixing things.	○	○	○	○	○
I am interested in what makes machines work.	○	○	○	○	○
Designing products or structures will be important in my future jobs.	○	○	○	○	○
I am curious about how electronics work.	○	○	○	○	○
I want to be creative in my future jobs.	○	○	○	○	○
Knowing how to use math and science together will help me to invent useful things.	○	○	○	○	○
I believe I can be successful in engineering.	○	○	○	○	○
Your future		NAI	NSI	I	VI
Physics: People study motion, gravity, and what things are made of. They also study energy, like how a swinging bat can make a baseball switch directions. They study how different liquids, solids, and gas can be turned into heat or electricity.		○	○	○	○
Environmental work: People study how nature works. They study how waste and pollution affect the environment. They also invent solutions to these problems.		○	○	○	○
Biology: People work with animals and plants and how they live. They also study farm animals and the food that they make, like milk. They can use what they know to invent products for people to use.		○	○	○	○
Veterinary work: People prevent disease in animals. They give medicines to help and get better and for animal and human safety.		○	○	○	○
Mathematics: People use math and computers to solve problems. They use it to make decisions in businesses and government. They use numbers to understand why different things happen, like why some people are healthier than others.		○	○	○	○
Medicine: People learn how the human body works. They decide why someone is sick or hurt and give medicines to help the person get better. They teach people about health, and sometimes they perform surgery.		○	○	○	○
Earth science: People work with the air, water, rocks, and soil. Some tell us if there is pollution and how to make the earth safer and cleaner. Other earth scientists forecast the weather.		○	○	○	○
Computer science: People write instructions to run a program that a computer can follow. They design computer games and other programs. They also fix and improve computers for other people.		○	○	○	○
Medical science: People study human diseases and work to find answers to human health problems.		○	○	○	○
Chemistry: People work with chemicals. They invent new chemicals and use them to make new products, like paints, medicine, and plastic.		○	○	○	○
Energy/electricity: People invent, improve and maintain ways to make electricity or heat. They also design electrical and other power systems in buildings and machines.		○	○	○	○
Engineering: People use science, math, and computers to build different products (everything from airplanes to toothbrushes). Engineers make new products and keep them working.		○	○	○	○

Note. SD: Strongly disagree; D: Disagree; NAD: Neither agree nor disagree; A: Agree; SA: Strongly agree; NAI: Not at all interested; NSI: Not so interested; I: Interested; & VI: Very interested