# Science, Technology, Engineering, and Mathematics (STEM) Career Interest as Influenced by Mental Rotation Skills and Mathematics Self-Efficacy of Students

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**Abstract**

The purpose of this descriptive and correlational study was to determine whether Science, Technology, Engineering, and Mathematics (STEM) career interest is influenced by mental rotation skills and mathematics self-efficacy. Three hundred thirty-two public secondary students of New Corella District, Division of Davao del Norte were selected as respondents through stratified random sampling. Adapted questionnaires were used to determine the level of mental rotation skills, mathematics self-efficacy, and the STEM career interest of students. Data were analyzed using mean, Pearson-r and regression analysis. The findings suggested that the students' mental rotation skills is poor. Students' mathematics self-efficacy in terms of mastery experiences, vicarious experiences, social persuasions, and physiological states are fairly evident. Moreover, the STEM career interest of students is evident. Furthermore, students' mathematics self-efficacy and STEM career interest have a significant relationship, while mental rotation skills and students' STEM career interest do not have a significant relationship. The results highlighted the importance of mental rotation skills and mathematics self-efficacy in improving the career interest of students in the field of STEM education. Teachers may employ a diverse array of strategies to cultivate students' interests in STEM careers for the future by fostering a supportive environment where students are encouraged not to be overly self-critical in pursuit of knowledge, instilling the essential confidence needed for them to pursue their career aspirations within STEM fields.

Keywords: Mathematics education; mental rotation skills; mathematics self-efficacy; STEM career interest; descriptive and correlational design; Pearson r; regression analysis; Davao del Norte; Philippines.

## 1. Introduction

Science, Technology, Engineering, and Mathematics (STEM) skills play a significant factor in a country's development. However, several research findings suggest that students have low interest in careers related to STEM (Mohammad et al., 2021). In Malaysia, STEM-related careers are prioritized to achieve a STEM-driven economy, but a study concluded that more than 30% of Malaysian students expressed a lack of interest in STEM (Shahali, 2020). Moreover, another study in Croatia revealed that the average interest in careers among students in STEM domains was generally low (Babarović, 2021). In the Philippines, the lack of interest among students in the areas of STEM is apparent (Punzalan, 2022). Research findings suggested that students are not interested in STEM with only 15% or 794 out of 5,197 senior high school students enrolled in it (Dumapias &Tabuzo, 2018). Factors like mental rotation skills and math self-efficacy influence interest, yet research is limited. Urgency arises from the growing issue of low STEM career interest. This study aims to provide insights and disseminate findings globally. It seeks to address challenges in fostering STEM interest among students, offering actionable recommendations. Through collaboration with educators, policymakers, and researchers, it aims to advance knowledge and tackle pressing issues in STEM education.

### 1.1. Statement of the Problem

The primary objective of this investigation was to evaluate the potential significant influence of mental rotation skills and mathematics self-efficacy on the STEM career interest of students. Specifically, it aimed to answer the following:

1. What is the level of mental rotation skills among students?
2. What is the level of mathematics self-efficacy of students in terms of mastery experience; vicarious experience; social persuasion; and physiological states?
3. What is the level of STEM career interest among students?
4. Is there a significant relationship between mental rotation skills and students' STEM career interest; and mathematics self-efficacy and students' STEM career interest?
5. Do mental rotation skills and Mathematics self-efficacy significantly influence students' STEM career interest?

### 1.2. Hypotheses

The following hypotheses were tested at a significance level of 0.05:
$H_{O1}$. There is no significant relationship between mental rotation skills and students' STEM career interest and mathematics self-efficacy and students' STEM career interest.
$H_{O2}$. Mental rotation skills and Mathematics self-efficacy do not significantly influence students' STEM career interest.

### 1.3. Theoretical and Conceptual Framework

This study was based on the concept of Moe (2021) which stated that mental rotation skills predict the interest of students in choosing STEM-related careers. This linkage was demonstrated based on the findings that the better the mental rotation skills of the participants were, the more they show interest in STEM areas. Moreover, Webb et al. (2007) also suggested that there exists a correlation between mental rotation skills and students' interest in STEM, both academically and in terms of career pursuits. This suggests that as one's mental rotation skills improves, one's interest in STEM improves as well. Meanwhile, Lin et al. (2019) concluded that mathematics self-efficacy is a good predictor of student's interest to pursue a STEM career. Additionally, Kifta (2022) also provides a congruent statement mentioning that low mathematics self-efficacy score of students corresponds to a low interest in pursuing STEM-related fields.

Figure 1 illustrates the conceptual model of the study, depicting the direct connection between mental rotation skills and mathematics self-efficacy. The model explores their potential impact on students' interest in STEM careers. In the diagram, the students' interest in STEM career serves as the response variable, gauging their perception of a conducive environment for pursuing a career in STEM. Mental rotation skills are the first independent variable which has the mental rotation skills score as its indicator (Vandenberg and Kuse, 1978). On the other hand, mathematics self-efficacy acts as the second independent variable. Usher & Pajares (2009) emphasized that mastery experiences, vicarious experiences, social persuasions, and physiological states are the four factors that measure students' mathematics self-efficacy.

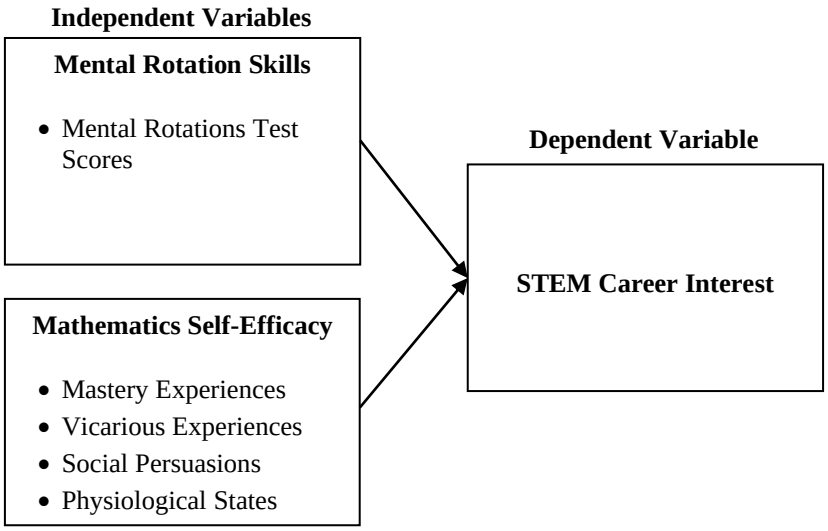


Figure 1. Conceptual Paradigm of the Study

## 2. Methodology

The study utilized a quantitative descriptive-correlational approach. The descriptive phase involved describing the levels of mental rotation skills, mathematics self-efficacy, and students' STEM career interest. Subsequently, the correlational analysis scrutinized whether mental rotation skills and mathematics self-efficacy significantly associate students' interest in STEM career. This investigation involved 277 students selected through stratified random sampling from five public secondary high schools in the New Corella District, Division of Davao del Norte. This research employed three adopted research instruments, which underwent rigorous evaluation for alignment with the research objectives. Expert validators conducted content validation to ensure validity, and reliability and validity were assessed through pilot testing with students from a public secondary high school in Davao del Norte. The Mental Rotation Test, consisting of 20 items, was adopted from Vandenberg and Kuse (1978) to measure mental rotation skills. The Mathematics Self-Efficacy survey, adapted from Usher and Pajares (2009), utilized a 5-point Likert scale across 24 items. The STEM Career Interest instrument, adopted from Kier et al. (2013), comprised 44 items using a 5-point Likert scale. The data gathering procedures involved obtaining permissions from relevant authorities, conducting orientations, and obtaining informed consent from respondents. Surveys were administered face-to-face, and the mental rotation test was conducted within a designated time frame. Data were checked, collated, and processed using authorized statistical software, with statistical techniques including mean, standard deviation, Pearson r, and multiple linear regression analysis utilized for data analysis and interpretation. Lastly, this study followed ethical guidelines to ensure the well-being of students during the conduct of the study.

## 3. Results and Discussions

This section thoroughly presents the results and discussion drawn from the collected and analyzed data. The discussion of the findings are as follows: Level of Mental Rotation Skills, Level of Mathematics Self-Efficacy, Level of STEM Career Interest, Relationship between Mental Rotation Skills and STEM

Career Interest and between Mathematics Self-Efficacy and STEM Career Interest of Students, and Regression Analysis on the Influence of Mental Rotation Skills and Mathematics Self-Efficacy on the STEM Career Interest of Students.

## Level of Mental Rotation Skills

Table 1. Level of Mental Rotation Skills of Students

| Indicator | SD | Mean | Description |
|---|---|---|---|
| Mental Rotation Test Score | 25.36 | 35.09 | Low |

Table 1 presents students' level of mental rotations skills in terms of mental rotation test (MRT) score. Based on the result above, the mean value obtained was 35.06, which was characterized as low. This suggests that the mental rotation skill among the students is poor. Moreover, the results got a standard deviation of 25.36, indicating a significant degree of dispersion among the students' test scores in relation to the mean value. It implies that the scores are spread out from the mean which further means that, in general, students have varying mental rotation skills. The present findings coincide with the study of Dawson (2019) which examined low mental rotation skills among students. The study revealed that students with low mental rotation skills often encounter challenges in visualizing and mentally manipulating objects in space. These difficulties can impede their performance in tasks requiring spatial reasoning and problem-solving abilities, especially in STEM-related fields where spatial visualization is crucial. However, Kurban and Yanik (2022) argued that students' low levels of mental rotation skills can be enhanced through targeted interventions and training. In a similar manner, the study conducted by Ha and Fang (2018) unveiled a high variation in mental rotation skills among students. Based on the investigation, there is a substantial degree of variability in the mental rotation abilities of students which means that while some exhibited high levels of mental rotation skills, others displayed poor levels of mental rotation skills, indicating a wide spectrum of cognitive capabilities in the spatial ability of individuals.

## Level of Mathematics Self-Efficacy

Table 2. Level of Mathematics Self-Efficacy of Students

| Indicators | SD | Mean | Descriptive Equivalent |
|---|---|---|---|
| Mastery Experiences | 0.61 | 3.37 | Moderate |
| Vicarious Experiences | 0.73 | 3.63 | High |
| Social Persuasions | 0.84 | 3.20 | Moderate |
| Physiological States | 0.93 | 2.98 | Moderate |
| **Overall** | **0.54** | **3.30** | **Moderate** |

The level of students' mathematics self-efficacy, as depicted in Table 2, reveals varied scores across different indicators. Vicarious experience achieved the highest mean score of 3.63, indicating a high level of mathematics self-efficacy associated with this aspect among students. In contrast, physiological states attained the lowest mean value of 2.98, reflecting a moderate level of mathematics self-efficacy concerning physiological states among students. The overall mean score of 3.30, characterized as moderate, suggests that students' perceptions of their mathematical abilities are significantly influenced by external sources such as peers, family, and friends rather than their own emotions and physical conditions. These findings are consistent with previous studies by Mamolo (2022) and Tobe (2023), which emphasized the importance of implementing strategies to enhance students' self-efficacy in mathematics. Additionally, research by Koponen

et al. (2021) and Schunk and Dibenedetto (2021) highlighted the significant role of vicarious experiences in shaping students' mathematics self-efficacy, underscoring the need for positive role models and supportive environments to bolster students' confidence in their mathematical abilities.

## Level of STEM Career Interest

Table 3. Level of STEM Career Interest of Students

| Indicator | SD | Mean | Description |
|---|---|---|---|
| STEM Career Interest | 0.96 | 3.52 | High |

Table 3 displays students' STEM career interest with an overall mean of 3.52, indicating a high level of interest in STEM domains, while a standard deviation of 0.96 suggests uniformity in responses. These findings resonate with studies by Demirkol et al. (2022), Cheng et al. (2021), and Kwon et al. (2023), indicating students' strong inclination towards technology, science, and mathematics professions. Factors contributing to this interest include the appeal of innovation, lucrative opportunities, and the potential for societal impact through scientific advancements. Additionally, Abd Rahman and Halim (2022) highlighted the need for collaborative efforts among educators, parents, counselors, and communities to nurture students' enthusiasm for STEM careers and guide them towards informed decisions in pursuing STEM-related paths.

## Relationship between Mental Rotation Skills and STEM Career Interest and between Mathematics Self-Efficacy and STEM Career Interest of Students

Table 4. Relationship between Mental Rotation Skills and STEM Career Interest and between Mathematics Self-Efficacy and STEM Career Interest

| Independent Variables | STEM Career Interest | | | |
|---|---|---|---|---|
| | r | p-value | Decision on Relationship | Decision on $H_o$ |
| Mental Rotation Skills | 0.042 | 0.484 | Not significant | Do not Reject |
| Mathematics Self-Efficacy | 0.624 | 0.000* | Significant | Reject |

* Significant at 0.05 level of significance (2-tailed)

Table 4 displays the relationship between mental rotation skills and stem career interest and between mathematics self-efficacy and stem career interest of students. The analysis reveals a negligible correlation (r = 0.042) between mental rotation skills and STEM career interest, with a non-significant p-value (0.484), suggesting no statistical evidence supporting a significant relationship. These results are consistent with studies by Sorby et al. (2018) and Phelps (2018), indicating that mental rotation skills are not determining factors for STEM career inclination. However, a moderate positive correlation (r = 0.624) exists between mathematics self-efficacy and STEM career interest, with a significant p-value (0.00), implying that improved math confidence corresponds to increased interest in STEM careers, aligning with research by Cribbs et al. (2021) and Blotnicky et al. (2018). These findings underscore the complex nature of factors influencing STEM career interest and highlight the need for further exploration in future studies.

Regression Analysis on the Influence of Mental Rotation Skills and Mathematics Self-Efficacy on the STEM Career Interest of Students

Table 5. Regression Analysis on the Influence of Mental Rotation Skills and Mathematics Self-Efficacy on the STEM Career Interest

| Independent Variables | Unstandardized Coefficients | | Standardized Coefficients | T | p-value | Remarks |
|---|---|---|---|---|---|---|
| | β | SE | Beta | | | |
| (Constant) | 0.927 | 0.146 | | | | |
| Mental Rotation Skills | 0.001 | 0.001 | 0.041 | 0.874 | 0.383 | Not Significant |
| Mathematics Self-Efficacy | 0.566 | 0.043 | 0.624 | 13.25 | 0.000 | Significant |

Table 5 presents regression results on how mental rotation skills and mathematics self-efficacy influence students' interest in STEM careers. Mathematics self-efficacy significantly impacts STEM career interest ($p = 0.000$; coefficient = 0.566), while mental rotation skills do not ($p = 0.383$). The combined model explains 39.2% of STEM interest variance, leaving 60.8% unexplained. These findings resonate with Kaleva et al. (2023) and McKinney et al. (2021), highlighting math self-efficacy's importance in predicting STEM career interest. In contrast, Sorby et al. (2018) found no predictive link between mental rotation skills and STEM career interest, suggesting educators prioritize enhancing students' math self-efficacy to cultivate STEM interest.

## 4. Conclusion

Based on the results, the level of mental rotation skills among students, as assessed by their scores on the mental rotation test, is poor. This suggests that students face significant challenges in visualizing and mentally manipulating objects in space, skills vital for success in STEM disciplines and various spatial reasoning tasks. Thus, addressing this deficit in mental rotation skills becomes imperative in nurturing students to explore STEM-related fields. Furthermore, the level of mathematics self-efficacy among students, as assessed through mastery experiences, vicarious experiences, social persuasions, and physiological states, is notably evident, with physiological states emerging as the indicator with the lowest score. Implementing strategies aimed at alleviating math-related anxiety and fostering positive emotional experiences can create a more supportive learning environment conducive to students' mathematical growth and success in STEM disciplines. Moreover, the STEM career interest of students is evident, which signifies their inclination towards pursuing professions in STEM fields. It suggests that students are cognizant of the dynamic nature of these fields and the potential for impactful contributions to society through innovation and problem-solving. Additionally, the analysis revealed that there is no significant relationship found between mental rotation skills and students' inclination towards STEM careers, a substantial association emerges between students' mathematics self-efficacy and their interest in STEM fields. Specifically, students with high mathematics self-efficacy exhibit a greater interest in pursuing careers in STEM. Interestingly, despite the lack of influence from mental rotation skills, mathematics self-efficacy significantly impacts students' STEM career interest. These results emphasize the role of students' self-efficacy in their mathematical abilities in shaping their aspirations for STEM-related careers. Overall, these findings emphasize the need for educators and policymakers to prioritize interventions aimed at enhancing students' mathematics self-efficacy, thereby nurturing their interest and engagement in STEM disciplines.

## 5. Recommendation

Building on the conclusions, it is highly recommended that students are encouraged to explore STEM education, recognizing its diverse career pathways and gaining insight through interdisciplinary projects, industry partnerships, and experiential learning opportunities. Teachers play a vital role in cultivating STEM career interest by creating supportive environments that promote enthusiasm and curiosity through engaging curriculum, mentorship, hands-on experiences, and collaboration among peers. School leaders should prioritize providing robust technical support to teachers, empowering them with professional development opportunities, technology integration resources, and collaboration platforms. DEpEd officials may initiate programs to enhance STEM education, advocating for curriculum integration, industry partnerships, and specialized teacher training. Future research should extend beyond mental rotation skills to explore factors like role models, educational resources, and socioeconomic influences for a holistic understanding of STEM interest.

## References

Abd Rahman, N., & Halim, L. (2022). STEM Career Interest: The Effect of Gender. Creative Education, 13(8), 2530-2543. doi: 10.4236/ce.2022.138160

Babarovic, T. (2021). Development of STEM vocational interests during elementary and middle school: a cohort-sequential longitudinal study. Journal of Career Development. https://doi.org/10.1177/08948453211036986

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, 1-15. doi:10.1186/s40594-018-0118-3

Cheng, L., Antonenko, P. P., Ritzhaupt, A. D., & MacFadden, B. (2021). Exploring the role of 3D printing and STEM integration levels in students' STEM career interest. British Journal of Educational Technology, 52, 1262-1278. https://doi.org/10.1111/bjet.13077

Cribbs, J., Huang, X., & Piatek‐Jimenez, K. (2021). Relations of mathematics mindset, mathematics anxiety, mathematics identity, and mathematics self‐efficacy to STEM career choice: A structural equation modeling approach. School Science and Mathematics, 121(5), 275-287. https://doi.org/10.1111/ssm.12470

Dawson, C. (2019). Tackling Limited Spatial Ability: Lowering One Barrier into STEM?. European Journal of Science and Mathematics Education, 7(1), 14-31. https://eric.ed.gov/?id=EJ1203669

Demirkol, K., Kartal, B., & Tasdemir, A. (2022). The Effect of Teachers' Attitudes towards and Self-Efficacy Beliefs Regarding STEM Education on Students' STEM Career Interests. Journal of Science Learning, 5(2), 204-215. https://doi.org/10.17509/jsl.v5i2.43991

Dumapias, A. & Tabuzo, V. T. (2018). Interest and Confidence in Mathematics and Science: Precursors in Choosing the STEM Strand. SSRN Electronic Journal, (5), doi:10.2139/ssrn.3359091

Ha, O., & Fang, N. (2018). Interactive virtual and physical manipulatives for improving students' spatial skills. Journal of Educational Computing Research, 55(8), 1088-1110. https://doi.org/10.1177/0735633117697730

Kaleva, S., Celik, I., Nogueiras, G., Pursiainen, J., & Muukkonen, H. (2023). Examining the predictors of STEM career interest among upper secondary students in Finland. Educational Research and Evaluation, 1-22. https://doi.org/10.1080/13803611.2022.2161579

Kier, M. W., Blanchard, M. R., Osborne, J. W., & Albert, J. L. (2014). The development of the STEM career interest survey (STEM-CIS). Research in Science Education, 44(3), 461-481. https://doi.org/10.1007/s11165-013-9389-3

Kifta, D. A. (2022). Analysis Student's Career Based on Social Cognitive Career Theory to Develop Students' STEM Career Interests. https://doi.org/10.31219/osf.io/erc9g

Koponen, T., Aro, T., Peura, P., Leskinen, M., Viholainen, H., & Aro, M. (2021). Benefits of integrating an explicit self-efficacy intervention with calculation strategy training for low-performing elementary students. Frontiers in psychology, 12, 714379. https://doi.org/10.3389/fpsyg.2021.714379

Kurban, F. & Yanik, H. (2022). Developing pre-service mathematics teachers' mental rotation skills through dynamic geometry software-supported instruction. Journal of Qualitative Research in Education, 22(31). https://doi.org/10.14689/enad.31.1603

Lin, L., Lee, T., & Snyder, L. A. (2018). Math self-efficacy and STEM intentions: A person-centered approach. Frontiers in psychology, 9, 2033. https://doi.org/10.3389/fpsyg.2018.02033

Mamolo, L. A. (2022). Online learning and students' mathematics motivation, self-efficacy, and anxiety in the "New Normal". Education Research International, 2022, 1-10. https://doi.org/10.1155/2022/9439634

McKinney, J., Chang, M. L., & Glassmeyer, D. (2021). Why females choose STEM majors: Understanding the relationships between major, personality, interests, self-efficacy, and anxiety. Journal for STEM Education Research, 4(3), 278-300. https://doi.org/10.1007/s41979-021-00050-6

Moe, A. (2021). Doubling mental rotation scores in high school students: Effects of motivational and strategic trainings. Learning and Instruction, 74, 101461. https://doi.org/10.1016/j.learninstruc.2021.101461

Mohammad, N. & Mat Sout, N. & Hasssan, K. & abu samah, Nadzirah & Kamaruddin, H. & md khalid, Rahayu & Azman, H. (2021). The perception of pre-university students on STEM. Journal of Physics: Conference Series. 1882. 012155. 10.1088/1742

Phelps, M. B. (2018). The Effects of Hands-on Activities on Middle School Females' Spatial Skills and Interest in Technology-based Careers Paper presented at 2018 ASEE Annual Conference & Exposition, San Antonio, Texas. doi: 10.18260/1-2--22053

Schunk, D. H., & Dibenedetto, M. K. (2021). Self-efficacy and human motivation. In Advances in motivation science (Vol. 8, pp. 153-179). Elsevier. https://doi.org/10.1016/bs.adms.2020.10.001

Sorby, S., Veurink, N., & Streiner, S. (2018). Does spatial skills instruction improve STEM outcomes? The answer is 'yes'. Learning and Individual Differences, 67(), 209–222. doi:10.1016/j.lindif.2018.09.001

Tobe, A. G. D. (2023). Interplay of mathematics self-efficacy, anxiety, creativity beliefs, and learning styles among college students: Implications for curriculum alignment. Journal of Namibian Studies: History Politics Culture, 33, 1725-1765. https://doi.org/10.59670/jns.v33i.2172

Usher, E. L., & Pajares, F. (2009). Sources of self-efficacy in mathematics: A validation study. Contemporary Educational Psychology, 34(1), 89–101.https://doi.org/10.1016/j.cedpsych.2008.09.0026596/1882/1/012155.

Vandenberg, S., & Kuse, A.R. (1978). Mental rotations: A group test of three-dimensional spatial visualization. Perceptual and Motor

Skills, 47, 599-604. DOI: 10.2466/pms.1978.47.2.599
Webb, R. M.; Lubinski, D.; Benbow, C. P. (2007). Spatial ability: A neglected dimension in talent searches for intellectually precocious youth. Journal of Educational Psychology, 99(2), 397–420. doi:10.1037/0022-0663.99.2.397