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Analysis of Spatial Reasoning Skills Using Newman's Error Framework

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ABSTRACT

Spatial reasoning is essential for STEM success and mathematical problem-solving. The lack of spatial reasoning skills among many college students impacts their academic performance, particularly in subjects that require it. The study assesses the level of spatial reasoning skills among college students, compares STEM and non-STEM completers, and investigates the difficulties they encounter in answering spatial reasoning tests to understand the reasons behind their struggles. Furthermore, it seeks to recommend strategies aligned with SDG 4: Quality Education to enhance students' spatial skills. A mixed-method approach was used and a spatial reasoning test was employed. Using the overall mean and standard deviation, it was revealed that the spatial skills of college students were above an intermediate score, with significant variation in spatial perception, visualization, and mental rotation. Based on the Mann-Whitney U test result, STEM completers outperformed non-STEM completers due to exposure to spatially demanding subjects. Moreover, with the help of Newman's Error Analysis framework, the study found that students struggle to comprehend or understand the wording of questions, which aligns with the PISA 2022 results for the Philippines. The study highlights the significance of spatial reasoning in academic achievement, suggesting that students can improve their skills by utilizing interactive tools and simplified problem-solving language.

INTRODUCTION

In the latest ranking of the Philippines in Programme for International Student Assessment (PISA) 2022 results, almost no students were top performers in mathematics, and only 16% of Filipino students attained at least level 2 proficiency in mathematics (OECD, 2023). Knowing that the PISA Math test includes spatial reasoning means that many Filipino students struggling with spatial problems lack sufficient proficiency. Empirical data show that many students, specifically in India, have difficulty converting three-dimensional objects into two-dimensional pictures or vice versa from two-dimensional to three-dimensional objects (Ma'rifatin *et al.,* 2019). A study in the United States also states that only 2.21 million out of 56.6 million students have high spatial abilities (Lakin & Wai, 2020). Furthermore, qualitative research in Indonesia shows that students struggle to solve spatial reasoning problems, especially students with low-level ability (Putri, 2020). Indeed, many students struggle with spatial reasoning, and having a low spatial reasoning ability is a global concern.

Over the past few decades, interest in spatial skills has grown because of its crucial role in various cognitive processes (Roach *et al.,* 2020). Spatial reasoning involves manipulating two-dimensional and three-dimensional objects (Bates *et al.,* 2023; Harris, 2023). Having difficulties in spatial reasoning, especially problems that require spatial skills, is a problem that needs to be addressed. To eliminate these difficulties and enhance students' spatial skills, aligned and appropriate activities can help them improve their skills (Kurt *et al.,* 2023). Hence, it is important to conduct a study exploring college students' difficulties in spatial tests to know why they struggle in spatial reasoning tests.

More so, Science, Technology, Engineering, and Mathematics (STEM) students are expected to have a higher spatial ability to excel in STEM-related courses than non-STEM students as they are more exposed to spatial problems (Septia *et al.,* 2019). Additionally, STEM and non-STEM completers showed significant differences in spatial reasoning skills (Lee *et al.,* 2019). Although STEM students are exposed to spatial problems, some still encounter difficulties with spatial reasoning. This skill is an essential element of success in STEM fields as it predicts the initial performance of the students. In addition, having strong spatial ability demonstrates advantages in STEM courses that allow them to discover, learn, and construct new ideas (Gilligan-Lee *et al.,* 2022).

Spatial reasoning difficulties are assessed using three indicators: Mental rotation (MR), Spatial visualization (SV), and Spatial perception (SP). It is also crucial to know if there is a significant difference in the spatial reasoning skills of STEM and non-STEM completers. Such difficulties can be recognized through the Cognitive Load Theory, which posits that students' working memory may become overloaded when attempting to answer complex spatial reasoning, further limiting their ability to solve problems effectively (Sweller, 1988). In addition, the significance of the spatial reasoning skill is reiterated in the Theory of Multiple Intelligences, specifically the

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visual-spatial intelligence individuals who depend on their spatial reasoning skills (Gardner, 2004), and Newman's error analysis a structured approach to identify errors in spatial reasoning (Newman, 1977).

Mental rotation is the ability to rotate an object and imagine how it is seen from one perspective into a new orientation (Johnson & Moore, 2020; Moen *et al.,* 2020). Students with difficulty rotating objects struggle to understand different perspectives and mentally rotate figures to fit a given perspective (Moè, 2021). Spatial visualization manipulates two-dimensional and three-dimensional objects (Herrera *et al.,* 2024; Harris, 2023). Students with low spatial visualization struggle to interpret drawings, understand geometric relationships, and mentally construct and deconstruct shapes (Lowrie *et al.,* 2019). Spatial perception is the ability to perceive and recognize the position of an object relative to other objects (Cha *et al.,* 2019). Those with low spatial perception may struggle to interpret distances and spatial relationships, making it challenging to navigate diagrams, graphs, and geometric problems (Parisi, 2024).

The study of spatial reasoning helps understand the student's possible difficulties in gathering quantitative and qualitative data. Skills like MR, SV, and SP can be measured through standardized assessments that will help reveal the performance and differences in students who are STEM and non-STEM completers (Margulieux, 2020; Atit *et al.,* 2020; Sisman *et al.,* 2020). Meanwhile, the qualitative data helps provide a better understanding of the difficulties faced by the students in spatial reasoning (Ryser, 2021). This mixed-methods approach, emphasizing the quantitative and qualitative results, will help better understand what the students face while answering spatial reasoning tests. (Slattery *et al.,* 2024).

Further, previous studies highlight the spatial reasoning skills of students in terms of gender (Harris *et al.,* 2021; Lauer *et al.,* 2019), year level (Casasola *et al.,* 2020; Kurt *et al.,* 2023), and technology-enhanced assessments (Supli & Yan, 2023; Sisman *et al.,* 2020). Additionally, several studies only focused on qualitative analysis and did not pursue a mixed-method design to explore better the students' spatial reasoning skills (e.g., Ramey *et al.,* 2020; Hertanti *et al.,* 2019; Yang *et al.,* 2020). However, there is a dearth of studies exploring the difficulties in spatial reasoning among college students and the effect of their strand in senior high school. That said, there is still work to be done to understand the specific difficulties experienced by the students (Farran *et al.,* 2024).

This study explores college students' common difficulties during spatial reasoning tests, providing strategies aligned with SDG 4: Quality Education to enhance students' spatial skills. The result of this study may help educators develop more spatial reasoning-related activities to help students lessen their difficulty answering spatial reasoning tests. Additionally, by identifying the specific problems in answering spatial reasoning, this study can help the students enhance their spatial skills in a world entirely of spatial patterns. Finally, this study can help future STEM students to reflect on how having high spatial skills is essential in their program.

The primary intent of this research paper is to determine the common difficulties experienced by college students. Most specifically, it will ascertain the level of spatial reasoning skills in terms of MR, SV, and SP, examine if there is a significant difference in spatial reasoning skills of STEM and non-STEM completers, and explore the common difficulties experienced by college students in answering spatial reasoning tests. This study will verify the hypothesis that there is no significant difference in the spatial reasoning skills of STEM and non-STEM completers at a .05 significance level.

MATERIALS AND METHODS

This section discusses research methods. It details the research design, data collection, and analysis. The methods were carefully selected to ensure accuracy, reliability, and validity.

Respondents

A population of 6180 college students enrolled in the first semester of the 2024-2025 academic year from one of the non-sectarian schools in Davao City was utilized. Using a sample size calculator, 362 college students were the respondents of the quantitative part of the study and were selected using cluster sampling. After that, 50 students with the lowest score were purposively selected for the qualitative stage.

The respondents were engineering and BSEd-Mathematics students who were STEM or non-STEM completers, and those officially enrolled who have completed at least nine units of Mathematics courses are included in the study. Dropout students, interns, and those who have not already taken at least three specializations were excluded from the study. Research respondents may withdraw their participation anytime, giving them control throughout the research process.

Instrument

This research study used modified questionnaires from Ramful *et al.* (2016) and 123 test for the mental rotation and spatial visualization test, JobTestPrep for the spatial visualization test, and JLSS mock examination questionnaires for the spatial perception test to assess the students' spatial reasoning skills. The research questionnaire was divided into two parts: a quantitative and qualitative part, with a 12-item multiple-choice test for the quantitative part and a 3-item constructive response test for each indicator for the qualitative part. The respondents were given a figure and tasked to create the desired figure based on the conditions. Finally, the respondents were asked to answer the follow-up questions. Respondents' responses were used to analyze common errors committed by students, indicating they struggled in this section.

The questionnaires were two-way validated to ensure clarity and alignment with research objectives. This involved expert content relevance review and pilot testing with a sample group to address item interpretation problems. After that, the researcher pilot-tested 30 students to measure the reliability of the test questionnaire. (α=.768). The items' internal consistency and content validity were tested using Cronbach Alpha to determine their reliability and statement appropriateness (Velasco & Villanueva, 2022). Cronbach's alpha within the $0.8 > \alpha \geq 0.7$ range is acceptable (Izah *et al.,* 2023). Following these processes helps the researchers produce more valid and reliable data results.

This study follows the scoring method of Ramful *et al.* (2016) and the interpretation table of Hasanah *et al.* (2024) in the spatial reasoning test, which consists of three steps. The first step was to score students' answers as 1 for correct and 0 for incorrect answers. The second step was counting the scores per indicator by averaging the scores per indicator to identify which spatial skill is most manifested and least manifested. Lastly, the level of spatial skills was achieved by summing the correct answers from those three spatial reasoning indicators. Following the method above, the scores of the students on the spatial reasoning test fell between 0 and 12. Then divide the interval into ten equal parts with a length of 1.2, and assign levels and descriptions to each section. To illustrate the level and determine the most and least manifested skill among the indicators, the researchers add another interval from 0 to 1 since the maximum score per indicator is one. Then, divide them into ten equal parts with the same description.

Table 1: Interpretation Table of the Level of Spatial Reasoning Skills of the Students

Level	SRTS Interval	IS Interval	Description
Level 10	$10.80 \leq SRTS < 12.00$	$0.90 \leq IS < 1.00$	Very high score
Level 9	$9.60 \leq SRTS < 10.80$	$0.80 \leq IS < 0.90$	High score
Level 8	$8.40 \leq SRTS < 9.60$	$0.70 \leq IS < 0.80$	Moderately high score
Level 7	$7.20 \leq SRTS < 8.40$	$0.60 \leq IS < 0.70$	Above intermediate score
Level 6	$6.00 \leq SRTS < 7.20$	$0.50 \leq IS < 0.60$	Slightly above intermediate score
Level 5	$4.80 \leq SRTS < 6.00$	$0.40 \leq IS < 0.50$	Slightly under an intermediate score
Level 4	$3.60 \leq SRTS < 4.80$	$0.30 \leq IS < 0.40$	Under the intermediate score
Level 3	$2.40 \leq SRTS < 3.60$	$0.20 \leq IS < 0.30$	Moderately low score
Level 2	$1.20 \leq SRTS < 2.40$	$0.10 \leq IS < 0.20$	Low Score
Level 1	$0.00 \leq SRTS < 1.20$	$0.00 \leq IS < 0.10$	Very low score

Note: SRTS and IS are Spatial Reasoning Test Score and Indicator Score, respectively. The intermediate scores of SRTS and IS are 6 and 0.5, respectively.

Design and Procedure

This research study utilized a mixed-methods design to better explore the specific difficulties faced by the students, specifically those who are STEM and non-STEM completers (Slattery *et al.,* 2024). Mixed-methods design combines quantitative and qualitative designs in a single study (Sharma *et al.,* 2023). This design is appropriate in this study as it helps to dig deeper and explore the level of spatial skills of the students, deliberately compare the performance of STEM and non-STEM completers, and determine the common difficulties encountered by college students.

In conducting the survey, the researcher sought permission from the Deans by sending a formal letter informing them that the research survey respondents were under their department. After the Dean approved the letter, the researcher gathered respondents by informing the professors of the engineering students and the BSED-Mathematics students. The researchers also set an appointment for when and where the survey was conducted. During the survey, one of the researchers read the test description what the test is all about, instructions for the test, and ensuring their privacy under the Data Privacy Act of 2012 while the other researchers distributed the test questionnaires. The respondents were given 20 minutes to answer the 12-item multiple-choice and 3-item constructive response tests. Lastly, the test questionnaires are collected after the allotted time.

The researchers assessed the students' spatial reasoning skills using the three indicators MR, SV, and SP. Together with the quantitative data, qualitative data was gathered by answering specific questions about the difficulties encountered by the respondents and particular strategies for answering the test. After collecting the data needed, the performance of STEM and non-STEM completers was compared to show a significant difference in their spatial reasoning skills. Lastly, the researcher interprets the gathered results and discusses the possible reasons why they encountered difficulties in answering the test and the potential effects of these results on their academic performance.

For the quantitative phase, statistical tools were used to analyze the data collected from the students' responses. This study used the mean and standard deviation of the students' scores in quantitative data to determine the level of their spatial reasoning skills. The Mann-Whitney U test was utilized to determine if there is a significant difference between STEM and non-STEM completers, since the data gathered is not normal. The Mann-Whitney U test is a popular way to compare the results of two unrelated groups with non-normal data (Dulalas *et al.,* 2025).

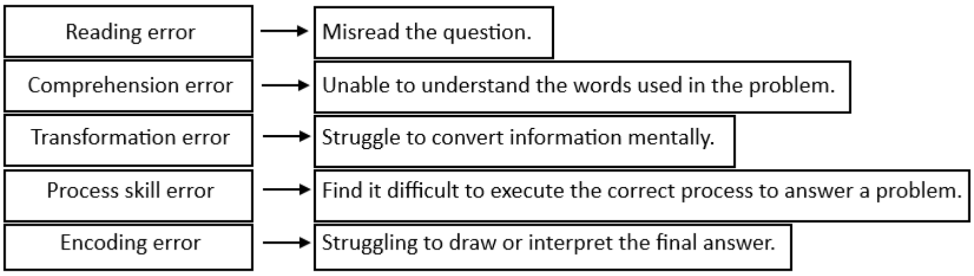

Figure 1: Newman's Error Analysis Framework in the Context of Spatial Reasoning

Meanwhile, for the qualitative phase, as presented in Figure 1, Newman's error analysis was used to ascertain if the difficulty was due to reading, comprehension, transformation, process skill, or encoding errors. If students respond that they misread the question and struggle to solve it, it is a reading error. It was a comprehension error if students said they didn't grasp the problem's language. Next, if students said they had trouble converting the information mentally, it was a transformation error. It was a process skill error if students said they had trouble following the correct steps to reach the right answer. Finally, if students said they had trouble drawing the final answer, it was an encoding error (Newman, 1977).

RESULTS AND DISCUSSIONS

The study assessed college students' spatial reasoning skills using mental rotation, spatial visualization, and spatial perception. These indicators show how students process and manipulate spatial problems. Understanding these skills is crucial to recognizing cognitive strengths and difficulties associated with learning in STEM and other spatially demanding subjects.

Table 2: Level of Spatial Reasoning Skills of College Students

Indicators	$\bar{x}$	**SD**
Mental rotation	0.69	0.27
Spatial visualization	0.57	0.29
Spatial perception	0.72	0.26
Overall	7.90	2.51

Presented in Table 2 are the mean and standard deviation of spatial reasoning test scores of the college students assessed through three different indicators. As presented, students acquired an overall average of 7.90 (sd = 2.51) in their spatial reasoning skills regarding mental rotation, spatial visualization, and spatial perception. This overall SRTS mean is under level 7 ($7.20 \leq SRTS < 8.40$) which is described as above intermediate score. This result tells that college students' spatial skills averaged above an intermediate level of spatial skill. This reveals that most of the students can answer and manipulate objects that are important in math-related programs.

Among the indicators, college students highly manifest spatial perception with a mean of 0.72 (sd= 0.26), which falls under level 8, which is described as a moderately high score. In the study of Parisi (2024), these students can interpret distances and spatial relationships, making it easy to navigate diagrams, graphs, and geometric problems. On the other hand, the least manifested skill of the students is spatial visualization, with a mean of 0.57 (sd = 0.29), which falls under level 6, which is described as slightly above intermediate score. Spatial perception and visualization show a two-level gap, indicating that students better recognize spatial relationships but struggle to manipulate objects mentally. Lowrie *et al.* (2019) stated that these students struggle with interpreting drawings, understanding geometric relationships, and problems that require mentally constructing and deconstructing shapes. The study by Lakin and Wai (2020) and Putri (2020) found that students often struggle with spatial reasoning, particularly spatial visualization. The large gap between spatial perception and visualization suggests that students better recognize spatial relationships from a fixed perspective but struggle mentally manipulating or transforming objects. The findings supported Sweller's (1988) Cognitive Load Theory, which suggests that complicated spatial tasks might overwhelm students' working memory. The study also supports Gardner's (2004) Multiple Intelligences theory, which states that people with low visual-spatial skills struggle to think in three dimensions. The lower performance in spatial visualization than spatial perception suggests that students may struggle with activities that require mentally manipulating or changing objects in space.

The findings show students have above-average spatial perception but struggle with spatial visualization. This gap suggests targeted instructional interventions to improve spatial visualization skills essential for math, engineering, and science problem-solving. Further, STEM performance and the ability to solve complex real-world problems requiring advanced spatial reasoning could improve by addressing these gaps. Lastly, the students may improve their cognitive and academic skills by integrating spatial training and giving spatial programs.

Correlation between STEM and Non-STEM

Table 3 shows the differences in the spatial reasoning skills of college students in their senior high school strand.

Table 3: Difference in Spatial Reasoning Skills of College Students by SHS Strand

Variable	Group	n	$\bar{x}$	SD	U	p
Spatial Reasoning Skills	STEM	195	8.23	2.41	13715	.009*
	Non-STEM	167	7.51	2.57		

**p<0.05*, significant*

The computed p-value is less than .05, so there is enough evidence to reject the null hypothesis. Hence, there is a significant difference in the spatial reasoning skills of STEM and non-STEM completers at a .05 significance level. It suggests that STEM students might be exposed to more spatial activities, highlighting the need for non-STEM programs to improve their spatial training.

The result indicates a statistically significant difference in the spatial reasoning skills between the two groups based on the Mann-Whitney U test (U=13715, p=.009). STEM completers (n=195) obtained a higher mean score $\bar{x}$=8.23(sd=2.41) compared to non-STEM completers (n=167) That obtained an overall average score of $\bar{x}$=7.51(sd=2.57). STEM students have better spatial reasoning due to their geometry, physics, engineering drawing, and data interpretation tasks. These subjects require mental manipulation, complex diagram interpretation, and abstract visualization, which train students to enhance their spatial skills.

This result supports the findings of Septia *et al.* (2019) that STEM students are expected to have higher spatial skills than non-STEM students, as their academic subjects present spatial problems. Del Cerro Velázquez and Méndez (2021) stated in their study that subjects like geometry and engineering drawing help STEM students to improve their spatial skills. Additionally, regular practice of visualization and reasoning tasks strengthens students' spatial skills over time. Lastly, the result of this study is also aligned with the result of Lee *et al.* (2019) that the spatial skills of STEM and non-STEM completers differ. These results emphasize the effect that curriculum design has on students' cognitive skill acquisition.

The results reveal that a student's educational background contributes significantly to developing spatial ability. The apparent difference between STEM and non-STEM completers verifies that consistent exposure to subjects that require spatial thinking strengthens these skills. This suggests that a well-designed curriculum significantly affects how students develop their spatial reasoning skills.

Using Newman's Error Analysis Framework of Spatial Reasoning Difficulties

This study investigates spatial reasoning cognitive issues, identifying potential causes such as misreading, misunderstanding, improper transformation, flawed processing, or encoding errors (Newman, 1977). Identifying these errors can tell us about the difficulties they experienced during the spatial reasoning test. The qualitative responses were categorized into five errors: reading error, comprehension error, transformation error, process skill error, and encoding error. The researcher considered one or more errors per item to ensure a balanced and comprehensive analysis of each student's response. By assessing students' cognitive difficulties and the frequency of these errors, the study aims to develop instructional ways to improve the spatial reasoning skills of the students. This method provides deeper insight into specific areas where students commonly struggle, allowing for more focused and effective teaching strategies and interventions.

Table 4: Distribution of Errors in terms of Mental Rotation, Spatial Visualization, and Spatial Perception

Type of Error	Number of Errors			Total Errors	%
	Mental Rotation	Spatial Visualization	Spatial Perception		
Reading	0	0	0	0	0.00
Comprehension	21	24	10	55	36.67
Transformation	16	14	13	43	28.67
Process skill	9	4	8	21	14.00
Encoding	11	6	14	31	20.67

Mental Rotation

Table 4 presents the distribution of errors made by the students in answering the test regarding mental rotation. In this problem, the students must rotate the illustration 180 degrees. One of the sample responses of the students' difficulties in this problem, which led to different errors, is that [R11] "I have difficulty in analyzing the image and the question." This response falls under comprehension error and transformation error, in which this student understood the words used in the question but struggled to grasp their meaning, which hindered them from proceeding to the next step. This means that students tend to make errors in comprehension and transformation because they have difficulties understanding the meaning of the words. On the other hand, another student responded [R1], "As you can see, I struggled drawing the resulting image because I hate drawing, [;] that for me was the most difficult thing I have encountered." which means he struggled to encode his answer. This means that this student has difficulty encoding his final answer, which leads to another difficulty. Students' inability to represent their answers visually indicates a weakness in translating their understanding into mathematical representations.

Spatial Visualization

In this part, students were asked to fold a figure and determine its orientation based on a specified condition. One of the responses, [R11], "It's [It is] hard when it comes with [to] imagining it to [be] folded regarding its specific conditions, [;] I am not that good with this type of situation. I need it to have an object at hand to visualize it rather than pure imagination only." This response falls under process skill error, where student find it challenging to fold an object mentally without a physical model. This means that this student has difficulty processing the answer, resulting in an error in process skills. Another response is, [R48], "I have a problem understanding the question because the question ask [asks] about the possible orientation "if the top side and left side contained four dots and a solid square respectively" and I don't understand it." The main problem for this student is how the question is being constructed, which is why he struggles to understand the question. The words used in the question are commonly used in mathematical problems. Students may struggle because they do not comprehend the question's structure, not because they do not know math. This suggests an issue in language processing that might limit their ability to apply mathematical knowledge.

Spatial Perception

In the spatial reasoning test regarding spatial perception, the questions required the students to complete an analogy under specific conditions. One of the students responded, [R42], "I don't [do not] know how to draw or illustrate my answer." Based on this response, the student finds it difficult to draw his answer, leading to an encoding error. This difficulty may indicate that some students struggle to visually represent their understanding of the problem. Another response is [R45] "Understanding the pattern of changes of the first figure and interpreting the changes to the missing figure." This response made by the student falls under process error and encoding error. Students find it challenging to understand the change in patterns, so finding the correct answer is difficult. This means that students struggle mentally to process their answers, leading them to make errors and hindering their ability to analyze mathematical problems critically.

In summary, most of the students' common errors are comprehension errors, and out of 150 responses, 36.27% of those responses fall under comprehension errors. This tells us that students find it challenging to comprehend problems given to them, which leads them to give the wrong answer. At the same time, students made no errors in reading, as this test focused on figures. On the other hand, the second lowest error made by the student is the process skill error, which accounted for 14% of all responses gathered. This tells that students know how to answer the problem, but find it challenging to do the process to come up with the correct answer.

Lastly, based on the findings, many students still struggle to comprehend the problem given to them. Even though students can read, that does not mean they understand what they read. This result is aligned with the findings of PISA 2022, where reading comprehension is low in the Philippines, showing a nationwide concern in students' ability to understand and comprehend words given to them (OECD, 2023). This highlights the need for improved teaching strategies that consider students' capacity to understand the problem and address this kind of difficulty. To address this problem, teachers can help by enhancing students' mathematical vocabulary and providing structured problem-solving strategies. Lastly, by incorporating real-life contexts in math problems and giving immediate feedback, ensure students receive the support they need to improve their comprehension skills and become confident in solving mathematical problems.

CONCLUSION

The findings of this mixed-methods study show that college students' spatial reasoning skills are above intermediate, with significant variation across the three indicators. Students performed best in spatial perception, reaching a moderately high level, indicating a strong ability to recognize spatial relationships and interpret visual-spatial information. Spatial visualization, the lowest-performing skill, was slightly above the intermediate level, suggesting students struggle with mentally constructing and deconstructing objects. Though lower than spatial perception, mental rotation scored above intermediate. According to Sweller's Cognitive Load Theory, mentally demanding spatial tasks may overwhelm students' working memory, making complex visualization harder. The results also support Gardner's Theory of Multiple Intelligences, particularly visual-spatial intelligence, which states that learners process spatial information differently.

Students are good at recognizing visual patterns but must improve their mental manipulation skills to succeed in STEM fields that require advanced spatial reasoning.

The study reveals that college students' spatial reasoning skills vary by senior high school strand. STEM completers exhibit better spatial reasoning due to their exposure to spatially demanding subjects like geometry, engineering, and physics. However, non-STEM completers may not benefit from consistent spatial task training. The study suggests that education is crucial for spatial reasoning development, and non-STEM programs should include spatial reasoning activities. Enhancing spatial training across all strands can help students succeed academically and professionally, as this skill is not only about how you mentally manipulate objects but also how organized your thoughts, plans, and ideas are.

Lastly, using Newman's error analysis, the researchers found that students' spatial reasoning performance, especially comprehension, is concerning. Students have more trouble understanding the problem than reading or encoding. While students can read and interpret figures, many cannot understand the meaning or process needed to solve spatial tasks. This matches the PISA 2022 results, where Filipino students scored low in reading comprehension, indicating a national issue with written information.

This suggests that students must improve their spatial skills, especially in spatial reasoning-related programs. This issue is crucial because limited spatial ability may impact academic performance in mathematics, engineering, architecture, and other professional disciplines. Students can physically and cognitively explore spatial relationships with building blocks, tangrams, origami, 3D modeling kits, and interactive puzzles. Mental rotation, diagram folding, visual pattern completion, and geometric transformation interpretation are spatial reasoning-related problems that may also help the students to improve their spatial skills — integrating spatial tasks into regular lessons, using dynamic geometry software like GeoGebra, and challenging students with real-world spatial problems. Furthermore, students' comprehension must be improved because misunderstanding problems constitute a significant obstacle to success. To address this, teachers should properly introduce mathematical vocabulary, use graphic organizers, simplify problem language without changing meaning, and practice word problem-solving. Teachers can use questioning to help students identify key information and rephrase problems. By improving this skill, educators can help students improve their spatial skills, which will help them to appreciate and develop a deeper understanding of mathematics, leading to improved academic performance and critical thinking skills.

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