



The Correlation Between Self-Efficacy and Mathematical Creative Thinking to Students' Spatial Ability

Vallencia¹, Bistari^{2*}, Rustam³

^{1,2,3}Universitas Tanjungpura, Indonesia

E-mail*: bistari@fkip.untan.ac.id

Abstract

Finding out how senior high school students' spatial abilities relate to their self-efficacy and mathematical creativity is the primary goal of this study. The purpose of this research was to identify the factors that affect students' spatial ability, with an emphasis on mathematical creativity and self-efficacy. The researchers in this study employed a correlational research design and quantitative approach. Maranatha Christian High School twelfth graders (n=96) were the subjects of the study, from which 37 were selected at random. A spatial ability test, a math creative thinking exam, and a self-efficacy questionnaire were the instruments used. Two methods that are often used for analyzing data are multiple correlation and Pearson product-moment correlation. First, the study found that there is a strong positive correlation between self-efficacy and spatial ability (Pearson Product-moment correlation = 0.809, > 0.325), and second, there is a strong positive correlation between mathematical creativity and spatial ability (Pearson Product-Moment correlation = 0.647, > 0.325). The multiple correlation coefficient for self-efficacy and mathematical creativity in relation to spatial ability is 0.809. This suggests a strong and favorable link. Future research may further explore variable relationships through qualitative analysis and improved, more specific instruments.

Keywords: Mathematics; Self-Efficacy; Mathematical Creative Thinking; Spatial Ability



INTRODUCTION

Intelligence is one of the factors behind successful learning at school, especially in learning math (Triutami et al. 2021). Intelligence is people's ability to understand and express themselves through their ideas (Gumilar and Nandi 2018). Howard Gardner (2006) stated that intelligence is an individual's ability to produce a product that has high cultural value, to provide effective and efficient solutions to real-world problems, and to find complex problems to solve. Multiple intelligences are one type of intelligence that needs to be considered. A person contains eight different intelligences, according to Gardner's book. Some of these include a critique of the multiple intelligences theory, different types of intelligence (e.g., linguistic, spatial, logical-mathematical, bodily-kinesthetic, personal), and the socialisation of intelligences through symbols (Gardner 2011). At the same time, spatial intelligence is a crucial intelligence for maths education.

You can't talk about spatial intelligence without also talking about spatial ability. Those who are really gifted in spatial intelligence have little trouble mentally constructing three-dimensional things. (Aksoy and Balbag 2023). Gardner stated that the essence of spatial intelligence is the ability to accurately comprehend, transform, and modify visuals, which, in the absence of pertinent physical inputs, are subsequently replicated by elements of one's visual experience (Gardner 2011). Linn and Petersen in Pavlovičová defined spatial intelligence as the skill to represent, transform, and remember symbolic and non-linguistic information. Furthermore, they stated that spatial ability is the ability to understand, remember, and communicate a spatial image, which includes three categories, namely spatial perception, mental rotation, and spatial visualization (NRC 2006; Pavlovičová, Bočková, and Laššová 2022).

Spatial ability plays a crucial role in life.. (Gagnier, Holochwost, and Fisher 2021). These include using spatial representations, navigating with maps, and more. Meanwhile, the correlation between spatial and mathematical abilities has long been investigated since the dawn of psychology by mapping the "structure of intelligence" (Burte et al. 2020; Young, Levine, and Mix 2018). Spatial intelligence, which includes the ability to remember, manipulate, and reason, is overshadowed by the current math curriculum, given the extensive evidence that spatial skills correlate with math performance (Gilligan-Lee, Hawes, and Mix 2022). According to this study, which focuses more on the issue of geometry, spatial aptitude, spatial visualization skills, and spatial or visuospatial reasoning are some of the elements that are essential for learning geometry (UZUN and ÖZTÜRK 2023). Research conducted by Passadelli etc. (Passadelli, Klonari, and Nikolarea 2022) in Junior High School students from 47 different public schools in Greece, both male and female students have low spatial perception. The same thing was revealed by Imaniar etc. (Imaniar, Karyanto, and Yusup 2021) through his research in Surakarta High School that students' spatial abilities are still so low, especially in the part of visualizing 3D based on 2D information.

According to scientists, it is not only cognitive factors that influence the process of learning mathematics, but also affective factors, which include students' beliefs, perceptions, and feelings about learning mathematics (Espina, Marbán, and Maroto 2024; Negara et al. 2021; Shone, Weldemeskel, and Worku 2023b). Many students dislike mathematics due to negative perceptions about math which assume that this subject is more difficult than other subjects, thus affects learning outcomes. (Shone, Weldemeskel, and Worku 2023a). Mathematical perceptions, attitudes, and success rates are based on prior experiences that encompass both emotive and cognitive aspects. One of the affective factors related to it is self-efficacy which will be discussed in this topic (Obafemi et al. 2023; Shone et al. 2023b; Siregar et al. 2023; Zakariya 2022). Bandura (Bandura 1977) defined self-efficacy as a person's perception of how well he or she is capable of performing a particular task in order to achieve a specific outcome or goal. It shows that they will try their best the greater the accomplishment or goal they are striving for. In mathematics, self-efficacy refers to students' confidence in their ability to solve mathematical problems involving a form of skill. (Baiduri and Usmiyatun 2023; Liu, Wu, and Zhao 2023). Students who have a positive and good perception of mathematics tend to be able to achieve better results, compared to students who do not have a good perception. (Quaye and Pomeroy 2022).

Likewise with self-efficacy. Students with high self-efficacy tend to put more effort into completing the tasks given to them. (Shone et al. 2023b). Bandura revealed that self-efficacy has 3 dimensions, which are magnitude or level, strength, and generality. (Bandura 1977). Magnitude related to the difficulty of a person adopting a behavior. Strength related to how confident a person is in their ability to perform a task. Generality related to the extent to which self-efficacy is positively related.

In addition to self-efficacy, spatial ability is also closely related to creative thinking, especially mathematical creative thinking. This is revealed through research by Aini etc. which shows that students with high spatial abilities are able to achieve a high level of creative thinking. (Aini et al. 2020). Firdausy et al (2021) stated that one of the causes of low activity in mathematics discussions, especially in geometry topic, is due to the lack of students' ability to think creatively. Based on his research, it was found that good creative thinking skills can also improve math learning achievement. Creative thinking is defined as the activity of using the mind to find and develop new things or ideas to solve a problem (Sugiyanto, Masykuri, and Muzzazinah 2018). Fluency, adaptability, and novelty are the three markers of mathematical creative thinking based on Silver's Torrance Tests of Creative Thinking (TTCT) (Siswono 2011). Fluency is indicated by the number of ideas generated on a question. Flexibility is indicated by changes in the approach taken in determining a response. Novelty refers to the novelty or originality of ideas put forward in response to a given question.

Previous studies have highlighted the importance of self-efficacy in supporting successful mathematics learning as well as mathematical creative thinking skills in promoting mathematical problem solving. On the other hand, spatial ability has been linked to success in mathematics, particularly in the third dimension. However, studies that integrate these three aspects are still limited. Most of the previous studies focused more on the relationship of self-efficacy to mathematics outcomes in general or on creative thinking skills in the context of problem solving without considering spatial aspects. In addition, so far no research has been found that explicitly examines the correlation between self-efficacy and mathematical creative thinking ability to spatial ability, especially for students at the high school level. In fact, understanding the relationship between these three variables is very important later to design learning strategies that can encourage spatial abilities through approaches that touch on the psychological and pedagogical aspects of students. Therefore, this research tries to provide a new perspective on how self-efficacy and mathematical creative thinking ability correlate with students' spatial ability together in the third dimension material.

METHOD

The research methodology in this study was quantitative and based on correlations. The researchers set out to determine if there was a connection between high school students' spatial ability, self-efficacy, and mathematical creativity. In Pontianak, at Maranatha Christian High School, the study was carried out. The sample size for the research was 96 students. Purposive sampling was employed in this study to select a sample that met specific criteria relevant to the research objectives. The criteria included students who had already received mathematics instruction related to spatial ability, and were considered to possess a measurable level of self-efficacy and mathematical creative thinking. The researcher selected class XII IIS 2 as the sample because it met the criteria based on preliminary information provided by the mathematics teacher, including learning progress, class participation, and assessment results. Although other classes such as XII IIS 1 or XII MIA were included in the population, XII IIS 2 was selected because it showed more consistent characteristics in line with the research variables, so that the sample could provide more accurate and focused data. Multiple correlation and Pearson Product Moment correlation were used to analyze the data.

Methods

Research Instrument

This study used data collection techniques in the form of self-efficacy questionnaire, mathematical creative thinking test, and spatial ability test. Each student will fill out a self-efficacy questionnaire to find out the student's level of self-efficacy in learning mathematics. In addition, they are also given several problems related to the third dimension to determine their mathematical creative thinking ability and spatial ability in working on these problems. After filling out the questionnaire and

working on the questions, their results will be analyzed using Pearson Product Moment correlation and multiple correlation to determine the correlation between the three variables tested.

The self-efficacy questionnaire consists of 12 statements prepared based on 3 indicators derived from the dimensions of self-efficacy with 6 positive statements and 6 negative statements shown in table 1. The measurement scale used in the questionnaire is a Likert scale with 5 alternative answers.

Table 1. *Indicators of Self-Efficacy*

Indicator	Positive Statements	Negative Statement
1. Confidence in ability to complete multiple tasks of varying difficulty	1,2	3,4
2. Confidence in solving math problems based on material learned during the learning process.	5,6	7,8
3. Convinced of every learning process that was gone through	9,10	11,12

The Mathematical Creativity Test consists of 3 descriptive questions. The questions are arranged according to the indicators shown in Table 2.

Table 2. *Indicators of Mathematical Creative Thinking*

Indicators	Questions Indicator	Questions Number
1. Fluency.	Students can give several alternative answers to a beam rib size problem.	1
2. Flexibility	Students can determine the area of a cube in a variety of ways that can demonstrates flexibility in thinking.	2
3. Novelty	Students can create a space known only by its volume.	3

The spatial ability test consists of 5 descriptive questions. The questions are arranged according to the indicators derived from the Linn and Petersen categories shown in Table 3.

Table 3. *Indicators of Spatial Ability*

Indicators	Questions Indicator	Questions Number
1. State the position between 3-dimensional building elements.	Students can state the position of an element against other elements in 3-dimensional space building problems	1
2. Identify and classify geometric figures.	Students can classify which is the right cube net and identify pairs of parallel sides in the cube net.	2
3. Visualize the position or shape of an object in geometry based on a certain point of view.	Students can visualize the cube's new position when rotated 180 degrees and draw it.	3
4. Construct and represent geometric models based on flat plane images in a spatial context.	Students can construct a cube based on a die-edged net and	4

	represent the side faces with the specified base appropriately.	
5. Investigate a geometry object.	Students can draw a figure based on the given information and investigate the number of figures in forming another figure.	5

Validity and reliability test

The validity test results for the self-efficacy questionnaire show 10 out of 12 statements are valid, for the creative thinking test 3 out of 3 items are valid, while for the spatial ability test 5 out of 5 items are valid. For invalid statements in the self-efficacy questionnaire, the statements in the sentence were revised. According to the Mathematical Creative Thinking test's difficulty level, one question is classified as easy, while two more are classified as medium. On the other hand, the spatial ability test indicates that two questions are in the medium group and three questions are in the easy category.

Reliability test using Cronbach's Alpha technique. If an instrument's Cronbach's alpha value is more than 0.6, it is regarded as dependable. The reliability test result for the self-efficacy questionnaire is 0.691, for the mathematical creative thinking test is 0.628, while for the spatial ability test is 0.723. Since both instruments have a reliability value greater than 0.6, the instruments are considered reliable.

Pre-requisite test

We do tests for normalcy, linearity, and multicollinearity as prerequisites. This analysis was carried out using the IBM SPSS Statistics 29 program. Examining the Tests of normality table is what the normalcy evaluation does. A normal distribution is assumed for a dataset when the significance value (Sig.) is greater than 0.05 ($\alpha = 0.05$). Data does not follow a normal distribution if the significance value (Sig.) is less than 0.05 ($\alpha = 0.05$). The table labelled "Deviation from Linearity" is what the linearity test looks at. The relationship between the two variables is considered linear if the significance value (Sig.) is greater than 0.05 ($\alpha = 0.05$). Conversely, if the value (Sig.) < 0.05 ($\alpha = 0.05$), the two variables are not linear. The multicollinearity test looks at the Collinearity Statistics table. If the VIF value > 10 , it is said that the variable has symptoms of multicollinearity. Conversely, if the VIF value < 10 , it is said that the variable does not have symptoms of multicollinearity.

Meanwhile, the hypothesis test used is the Pearson Product Moment Correlation and Multiple Correlation tests. If the value of Pearson Product Moment Correlation (Sig.) < 0.05 , H_0 is rejected. It means, there is a significant correlation between self-efficacy and spatial thinking or mathematical creative thinking and spatial thinking. If $r_{count} > r_{table}$, then H_0 is rejected, which means there is a significant correlation between self efficacy and mathematical creative thinking to spatial thinking.

RESULTS

Descriptive analysis

The acquisition of self-efficacy questionnaire scores is mostly in the moderate category, namely 59.5%. This is supported by the average score of 35.72. From this average, it can be seen that the students' self-efficacy is in the moderate category. The acquisition of mathematical creative thinking test scores is mostly in the moderate category, which is 58.55%. This is supported by the average score of 7.02. From this average, it can be seen that students' creative thinking is in the moderate category. Meanwhile, the acquisition of spatial ability scores was mostly in the good category, which amounted to 64.32%. This is supported by the average score of 12.86. From this average, it can be shown that students' spatial abilities are in the good category.

Pre-requisite test

A significant value of 0.331 ($0.331 > 0.05$) was returned by the normalcy test of the self-efficacy measure. A significant value of 0.065 ($0.065 > 0.05$) was returned by the normalcy test of the

mathematical creative thinking variable. The result of the significance value for the normality test of the spatial ability variable is 0.060 ($0.060 > 0.05$), so that the data can be declared have a normal distribution.

The significance value for the linearity test between self-efficacy (X1) and spatial ability (Y) is 0.138 ($0.138 > 0.05$), indicating a linear relationship between the two variables. Similarly, the significance value for the linearity test between mathematical creative thinking (X2) and spatial ability (Y) is 0.128 ($0.128 > 0.05$), which also confirms a linear relationship between these variables.

The results of the VIF value for the multicollinearity test between self-efficacy (X1), mathematical creative thinking (X2), and spatial ability (Y) amounted to 2,814 ($2,814 < 10$) so it can be stated that there are no symptoms of multicollinearity in the three variables.

Hypothesis test

From the results of the prerequisite analysis test, both variables have met the criteria and conditions established for the conduct of hypothesis test. This hypothesis test is used to test whether there is a relationship between self-efficacy and mathematical creative thinking with students' spatial abilities. Hypothesis testing was conducted using Pearson Product Moment Correlation and Multiple Correlation.

Table 4. *Hypothesis Test 1*

		Correlations	
		Self-efficacy	Spacial Ability
Self-efficacy	Pearson Correlation	1	.809**
	Sig. (2-tailed)		<.001
	N	37	37
Spacial Ability	Pearson Correlation	.809**	1
	Sig. (2-tailed)	<.001	
	N	37	37

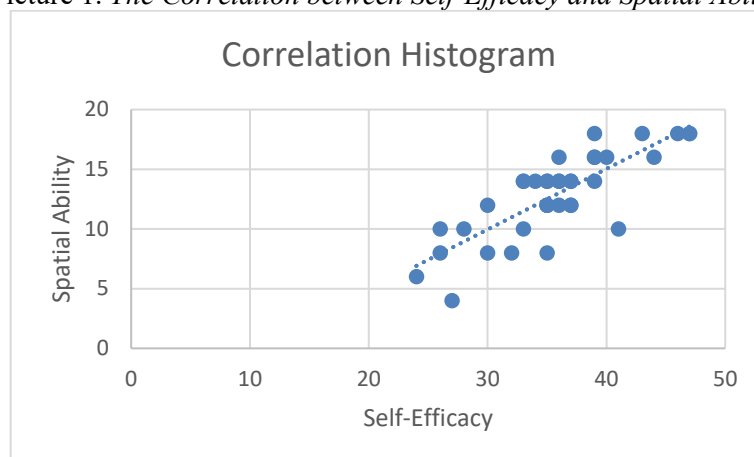
** . Correlation is significant at the 0.01 level (2-tailed).

Table 4 shows that self-efficacy and spatial competence are correlated. According to the results of the preceding table of correlation tests, the p-value for the association between self-efficacy and spatial ability is less than 0.01—well below the generally accepted cutoff. It is very unlikely that the observed link is due to chance alone, since this indicates a statistically significant correlation. Confidence in one's abilities and proficiency with spatial relationships are significantly correlated. Since the p-value is less than 0.05, we may reject the null hypothesis (H_0) that there is no relevant relationship between self-efficacy and spatial ability. That there is a strong correlation between the two variables is supported by this, which is an alternative hypothesis (H_1).

The results point to a strong positive relationship between self-efficacy and spatial ability, with a Pearson correlation value of $r = 0.809$. Students' spatial proficiency improves in tandem with their levels of self-efficacy. With 37 participants in the dataset, the crucial value (r table) used in the test is 0.325.. Because the calculated correlation coefficient is greater than the r table ($0.809 > 0.325$), this result is not only statistically significant but also shows strong practical significance.

To illustrate the correlation between self-efficacy and spatial ability, a comparison of self-efficacy scores with spatial ability is shown in the following histogram.

Picture 1. The Correlation between Self-Efficacy and Spatial Ability



The results of this study indicate that self-efficacy plays an important role in students' spatial reasoning abilities, especially in learning mathematical concepts such as three-dimensional geometry. Therefore, increasing students' self-efficacy can be an effective approach to improving their spatial abilities in mathematics.

Table 5. Hypothesis Test 2

		Mathematical Creative Thinking	Spatial Ability
Mathematical Creative Thinking	Pearson Correlation	1	.647**
	Sig. (2-tailed)		<,001
	N	37	37
Spatial Ability	Pearson Correlation	.647**	1
	Sig. (2-tailed)	<,001	
	N	37	37

** . Correlation is significant at the 0.01 level (2-tailed).

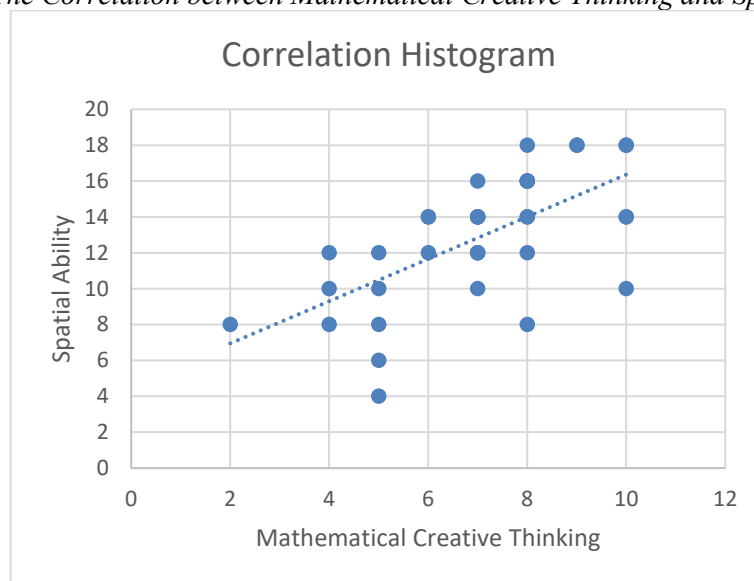
Table 5 shows the relationship between spatial ability and mathematical creativity. A p-value of less than 0.01 (below the significance level of 0.05), indicates a relationship between the two variables, as seen in the correlation test results table. Therefore, we can confidently say that the relationship exists, meaning that there is a meaningful relationship between students' ability to think creatively in mathematics and their spatial ability.

Since the significance value is less than 0.05, the null hypothesis (H_0), which states that there is no significant correlation between mathematical creative thinking and spatial abilities, is rejected. This leads to the acceptance of the alternative hypothesis (H_1) that there is indeed a significant correlation between the two variables.

From these results, it was also found that the Pearson correlation coefficient was $r = 0.647$, indicating a strong and positive correlation. This means that students who demonstrate higher levels of creative thinking in mathematics also tend to demonstrate higher levels of spatial ability. The critical value of r (table r) for a sample size of $N = 37$ is 0.325. Since the calculated $r >$ table r ($0.647 > 0.325$), this correlation is not only statistically significant but also strong.

To illustrate the correlation between mathematical creative thinking and spatial ability, a comparison between mathematical creative thinking scores and spatial ability can be seen in the following histogram.

Figure 2. The Correlation between Mathematical Creative Thinking and Spatial Ability



The results of this study indicate that mathematical creative thinking skills are closely related to spatial abilities, which play an important role in understanding and solving complex mathematical problems, especially those involving spatial reasoning, such as geometry and three-dimensional object visualization.

Table 6. Hypothesis Test 3

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.809 ^a	.654	.634	2.145	.654	32.158	2	34	<.001

a. Predictors: (Constant), Mathematical Creative Thinking, Self-efficacy

Table 6 shows the correlation between self-efficacy, mathematical creative thinking, and spatial ability. From the correlation test table, it can be seen that the significance value (p-value) for the model is less than 0.01, which is well below the conventional threshold of 0.05. Since the significance values for the three variables are below 0.05 ($p < 0.05$), the null hypothesis (H_0), which assumes that there is no significant relationship between the variables, is rejected. This indicates that there is a strong and statistically significant relationship between self-confidence, mathematical creative thinking, and spatial ability.

With an R value of 0.809, we can conclude that there is a strong and positive relationship between spatial ability (dependent variable) and the independent variables of self-confidence and mathematical creativity. This means that when students have high self-confidence and strong mathematical creativity, they are more likely to demonstrate higher spatial ability.

In addition, the coefficient of determination (R^2) is 0.654, meaning that approximately 65.4% of the variance in spatial ability can be collectively explained by self-confidence and mathematical creativity. This shows that the contribution of the two independent variables to spatial ability is not only statistically significant but also practically meaningful.

In conclusion, the results of this study support the idea that students' belief in their abilities (self-efficacy) and their ability to think creatively in mathematics play an important role in shaping their spatial reasoning abilities. Educational efforts to strengthen these two aspects can result in significant

improvements in students' overall spatial abilities, especially in mathematical contexts such as geometry or three-dimensional visualization.

DISCUSSION

The correlation between self-efficacy and spatial ability

In a number of studies, it has been found that self-efficacy plays an important role in positively impacting effort, perseverance, motivation, and individual performance. Directly, self-efficacy has an influence on increasing individual perseverance. Indirectly, self-efficacy provides motivation to learn, which in turn increases competence. (Street, Malmberg, and Schukajlow 2024). The relationship between self-confidence and academic achievement is particularly prominent in the context of mathematics, a subject that many students consider intellectually complex and emotionally exhausting. High levels of self-confidence are consistently identified as a strong predictor of student motivation for success in mathematical problem solving, influencing not only their persistence and use of strategies but also their willingness to engage in challenging tasks and overcome anxiety related to learning mathematics. (Holenstein, Bruckmaier, and Grob 2021). When it comes to spatial ability, those with high self-efficacy are believed to be able to generate higher confidence in their ability to obtain good results. In contrast, low self-efficacy is associated with fear of failure. For students who have experienced failure in math, they will certainly feel that they will not be able to produce better results in math. This is what causes the difference between the spatial mathematics ability of students with high and low self-efficacy.

Prior to performing the correlation test, the normality and linearity tests were performed as part of the study. The precondition test results demonstrated that the data on self-efficacy and spatial ability were linear and regularly distributed. Pearson Product Moment Correlation was then used to perform the correlation test. A significance value of less than 0.01 and a Pearson coefficient value of 0.809 were derived from the hypothesis testing findings. Based on the pearson coefficient value ($r_{count} 0.809 > r_{table} 0.325$) and the significance value ($0.01 < 0.05$), it can be said that there is a strong correlation between students' spatial abilities and self-efficacy in class XII IIS-2 Maranatha Christian High School.

As shown in the **Figure 1** in the result section, it can be seen that the distribution of the scatterplot points leads to the upper right and is on the same line. This shows that self-efficacy and spatial ability have a positive correlation, which means that the higher the self-efficacy of the students, the higher the level of spatial ability of the students. This is in line with the research of Liu etc. and Negara etc.. (Liu et al. 2023; Negara et al. 2021) which states that there is a positive correlation between self-efficacy and students' math scores. The higher students' confidence in their learning process, the higher their math scores.

The correlation between mathematical creative thinking and spatial ability

Problem-solving skills are at the core of mathematics education at the elementary school level. When students engage in solving mathematical problems, creative thinking allows them to make connections between different components of the problem and explore various solution paths. Therefore, fostering creativity is essential in teaching mathematics to young students. (DeVink et al. 2022). Spatial abilities allow individuals to mentally visualize, structure, interpret, and reason about spatial relationships in both real-world and imagined environments. These cognitive skills are frequently used in daily activities, such as putting together furniture or finding one's way from place to place (Atit et al. 2022) Mathematical creativity and spatial abilities play an important role in developing a student's mathematical understanding. Creative thinking helps students explore various strategies and make meaningful connections in solving mathematical problems, while spatial abilities improve their ability to visualize and argue about the relationships between objects and space. Together, these cognitive abilities contribute to a more holistic approach to mathematics learning, enabling young students not only to solve problems effectively but also to apply mathematical thinking in real-life contexts.

Prior to the correlation test, the normality and linearity tests were performed as part of the analysis process. The prerequisite test results demonstrated that the data on mathematical creativity and spatial aptitude were linear and regularly distributed. Pearson Product Moment Correlation was then used to perform the correlation test. A significance value of less than 0.01 and a Pearson coefficient value of 0.647 were derived from the hypothesis testing findings. Based on the significance value ($0.01 < 0.05$) and the pearson coefficient value ($r_{count} 0.647 > r_{table} 0.325$), it can be said that students in class XII

IIS-2 Maranatha Christian High School have a strong correlation between their spatial abilities and mathematical creative thinking.

As shown in the **Figure 2** in the result section, it can be seen that the distribution of the scatterplot points leads to the upper right and is on the same line. This shows that creative mathematical thinking and spatial ability have a positive correlation, which means that the higher the level of students' creative mathematical thinking, the higher the level of students' spatial ability. This is in line with Sbaih's research (Sbaih 2023) which was conducted among mathematics students at one of the universities. The study found a positive correlation between the level of mathematical creative thinking and mathematics achievement where the level of mathematical creative thinking increases along with academic development.

The correlation between self-efficacy and mathematical creative thinking to spatial ability

Understanding the correlation between self-confidence, mathematical creative thinking, and spatial abilities is crucial in developing mathematics education, especially in improving higher-order thinking skills among students. Research shows that self-confidence significantly affects students' motivation, perseverance, and creative performance in mathematical problem solving. (Street et al. 2024). The study conducted by Yang, Maeda, and Gentry (2024) Stating that confidence in mathematics plays an important role in influencing students' mathematical achievement. Students must have good motivation and confidence in order to encourage achievement in education, especially in mathematics.

In addition, mathematical creative thinking has been recognized as an important element in improving students' adaptability and originality in facing complex mathematical tasks, with those who have strong creative self-confidence often producing more innovative solutions. (Meier et al. 2024). At the same time, spatial ability serves as a foundational skill in supporting mathematical reasoning and mental visualization, particularly in tasks involving geometric and spatial structures (Lowrie et al., 2020). Moreover, the concept of spatial self-efficacy—students' belief in their spatial skills—further integrates motivational and cognitive domains, indicating that confidence in one's spatial reasoning can directly affect spatial performance and, by extension, mathematical outcomes (Arıkan and Çetin 2024). Students' understanding of the characteristics of spatial shapes is still weak, as students are limited to relying on their imagination. This could be due to the fact that the teaching received by students has not yet reached a higher level (Yanuarto and Iqbal 2022).

Prior to the correlation test, the normality and multicollinearity tests were performed as part of the analysis process. The precondition test results demonstrated that the data on self-efficacy, mathematical creativity, and spatial ability were normally distributed and free of multicollinearity symptoms. Multiple correlations were then used to perform the correlation test. A multiple correlation value of 0.809 and a significance value of less than 0.01 were derived from the hypothesis testing results. When viewed from the significance value ($0.01 < 0.05$) and the value of $R = 0.809$, it can be concluded that there is a significant correlation between self-efficacy and mathematical creative thinking to the spatial abilities of students in class XII IIS-2 Maranatha Christian High School which falls into a very strong category.

CONCLUSION

The conclusions of this study are (1) there is a positive and significant correlation between self-efficacy and spatial ability with a Pearson Product Moment correlation value of $0.809 > 0.325$, (2) there is a positive and significant correlation between mathematical creative thinking and spatial ability with a Pearson Product Moment correlation value of $0.647 > 0.325$, (3) there is a positive and significant correlation between self-efficacy and mathematical creative thinking to spatial ability with a multiple correlation value of 0.809. This research can be a reference material for future research with similar topics. The practical benefits are expected that this research can be useful for the learning process of mathematics, which focuses not only on cognitive learning, but also on affective development. In addition, teachers as instructors also need to create more interesting learning to develop students' creative thinking in solving things around mathematical problems. In future research, it can be developed again to conduct a more in-depth qualitative analysis in order to explore more deeply the relationship between each existing variable, as well as refining the instruments used to be more specific.

REFERENCES

- Aini, A. N., M. Mukhlis, A. M. Annizar, M. H. D. Jakaria, and D. D. Septiadi. 2020. "Creative Thinking Level of Visual-Spatial Students on Geometry HOTS Problems." *Journal of Physics: Conference Series* 1465(1):1–6. [DOI 10.1088/1742-6596/1465/1/012054](https://doi.org/10.1088/1742-6596/1465/1/012054)
- Aksoy, Kadir, and Mustafa Zafer Balbag. 2023. "Examination of the Relationship Between Science Fiction Self-Efficacy and Spatial Ability of Science Teacher Candidates." *Acta Didactica Napocensia* 16(1):157–69. [doi: 10.24193/adn.16.1.11](https://doi.org/10.24193/adn.16.1.11).
- Arıkan, Alaattin, and Turhan Çetin. 2024. "Psychometric Properties of the Spatial Skills Self-Efficacy Scale: A Validity and Reliability Study." *Thinking Skills and Creativity* 52. doi: <https://doi.org/10.1016/j.tsc.2024.101555>.
- Atit, Kinnari, Jason Richard Power, Terri Pigott, Jihyun Lee, Elyssa A. Geer, David H. Uttal, Colleen M. Ganley, and Sheryl A. Sorby. 2022. "Examining the Relations between Spatial Skills and Mathematical Performance: A Meta-Analysis. *Psychon Bull Rev* 29." *Psychonomic Bulletin & Review* 29:699–720.
- Baiduri, and Usmiyatun. 2023. "Self-Concept, Self-Efficacy, and Academic Achievement of Prospective Mathematics and Biology Teachers." *European Journal of Education and Pedagogy* 4(6):106–12. doi: [10.24018/ejedu.2023.4.6.744](https://doi.org/10.24018/ejedu.2023.4.6.744)
- Bandura, A. 1977. "Self-Efficacy: Toward a Unifying Theory of Behavioral Change." *Psychological Review* 84(2):191–215. [doi: https://doi.org/10.1037/0033-295X.84.2.191](https://doi.org/10.1037/0033-295X.84.2.191).
- Burte, Heather, Aaron L. Gardony, Allyson Hutton, and Holly A. Taylor. 2020. "Elementary Teachers' Attitudes and Beliefs about Spatial Thinking and Mathematics." *Cognitive Research Principles and Implications* 5(1):1–18. [doi: 10.1186/s41235-020-00221-w](https://doi.org/10.1186/s41235-020-00221-w).
- DeVink, Isabelle C., Robin H. Willemsen, Ard. W. Lazonder, and Evelyn H. Kroesbergen. 2022. "Creativity in Mathematics Performance: The Role of Divergent and Convergent Thinking." *British Journal of Educational Psychology* 92:484–501. [doi: https://doi.org/10.1111/bjep.12459](https://doi.org/10.1111/bjep.12459).
- Espina, Estefanía, José M. Marbán, and Ana Maroto. 2024. "The Affective Domain in Mathematics in Children with Dyscalculia: A Systematic Review." *Quadrante: Revista de Investigação Em Educação Matemática* 32(2):106–29. [doi: 10.48489/quadrante.29943](https://doi.org/10.48489/quadrante.29943).
- Firdausy, Ainun Rahma, Triyanto, and Diari Indriati. 2021. "Creative Thinking Based on Mathematical Reasoning Ability in Solving Geometry Problems in High School." *International Conference of Mathematics and Mathematics Education* 597:14–24. s
- Gagnier, Kristin Michod, Steven J. Holochwost, and Kelly R. Fisher. 2021. "Spatial Thinking in Science, Technology, Engineering, and Mathematics: Elementary Teachers' Beliefs, Perceptions, and Self-Efficacy." *Journal of Research in Science Teaching* 59(1):95–126. <https://doi.org/10.1002/tea.21722> Digital Object Identifier (DOI).
- Gardner, Howard. 2006. *Changing Minds: The Art and Science of Changing Our Own and Other People's Minds*. New York: Harvard Business School Press.

- Gardner, Howard. 2011. *Frames of Mind: The Theory of Multiple Intelligences*. New York: Basic Books.
- Gilligan-Lee, K. A., Z. C. K. Hawes, and K. .. Mix. 2022. "Spatial Thinking as the Missing Piece in Mathematics Curricula." *Npj Sci. Learn* 7(10):1–4. doi: <https://doi.org/10.1038/s41539-022-00128-9>.
- Gumilar, Y. H., and N. Nandi. 2018. "The Student's Spatial Intelligence Level in Senior High School." *IOP Conference Series: Earth and Environmental Science* 145(1):1–6. doi : [doi : 10.1088/1755-1315/145/1/012094](https://doi.org/10.1088/1755-1315/145/1/012094)
- Holenstein, Mathias, Georg Bruckmaier, and Alexander Grob. 2021. "How Do Self-Efficacy and Self-Concept Impact Mathematical Achievement? The Case of Mathematical Modelling." *British Journal of Educational Psychology* 92:155–74. doi: <https://doi.org/10.1111/bjep.12443>.
- Imaniar, N., P. Karyanto, and Y. Yusup. 2021. "Spatial Thinking Profile for 2017 Surakarta Senior High School." *IOP Conference Series: Earth and Environmental Science* 683(1):1–7. doi : [10.1088/1755-1315/683/1/012036](https://doi.org/10.1088/1755-1315/683/1/012036)
- Liu, Jiaying, Yutong Wu, and Fangxian Zhao. 2023. "The Impact of Self-Efficacy on Mathematics Academic Performance among Chinese High School Students." *Proceedings of the International Conference on Global Politics and Socio-Humanities* 299–306. doi: [10.54254/2753-7048/21/20230172](https://doi.org/10.54254/2753-7048/21/20230172).
- Meier, Michaela A., Anna Ehrenguber, Lara Spitzley, Nils Eller, Christina Reiterer, Martha Rieger, Hannah Skerbinz, Florentina Teuschel, Marc Wiemer, Stephan E. Vogel, and Roland H. Grabner. 2024. "The Prediction of Mathematical Creativity Scores: Mathematical Abilities, Personality and Creative Self-Beliefs." <https://www.sciencedirect.com/journal/learning-and-individual-differences> 113. doi: h DOI: [10.1016/j.lindif.2024.102473](https://doi.org/10.1016/j.lindif.2024.102473)
- Negara, H. R. P., E. Nurlaelah, W. Wahyudin, T. Herman, and M. Tamur. 2021. "Mathematics Self Efficacy and Mathematics Performance in Online Learning." *Journal of Physics: Conference Series* 1882(1):1–5. DOI: [10.1088/1742-6596/1882/1/012050](https://doi.org/10.1088/1742-6596/1882/1/012050)
- NRC. 2006. *Learning to Think Spatially*. Washington DC: United States of America.
- Obafemi, K. E., U. T. Saadu, A. Adesokan, O. Yahaya, J. T. Sulaiman, T. O. Obafemi, and F. M. Yakubu. 2023. "Self-Efficacy of Pupils ' Academic Achievement." *Indonesian Journal of Teaching in Science* 3(2):113–20. doi: [10.17509/ijotis.v3i2](https://doi.org/10.17509/ijotis.v3i2).
- Passadelli, Anthonoula-styliani, Aikaterini Klonari, and Ekaterini Nikolarea. 2022. "Spatial and Geospatial Thinking of Secondary Education Students in Greece." *Research Journal of Education* 8(4):80–85. doi: <https://doi.org/10.32861/rje.84.80.85>.
- Pavlovičová, Gabriela, Veronika Bočková, and Katarína Laššová. 2022. "Spatial Ability and Geometric Thinking of the Students of Teacher Training for Primary Education." *TEM Journal* 11(1):388–95. DOI: [10.18421/TEM111-49](https://doi.org/10.18421/TEM111-49)

- Quaye, Jeffery, and David Pomeroy. 2022. "Social Class Inequalities in Attitudes towards Mathematics and Achievement in Mathematics Cross Generations: A Quantitative Bourdieusian Analysis." *Educational Studies in Mathematics* 109:155–75. doi: <https://doi.org/10.1007/s10649-021-10078-5>.
- Sbaih, Amany Derar. 2023. "Creative Thinking in Students of Mathematics in Universities and Its Relationship with Some Variables." *Perspectives of Science and Education* 64:108–24. doi: [10.32744/pse.2023.4.7](https://doi.org/10.32744/pse.2023.4.7).
- Shone, Enkosa Terefe, Fisseha Mikre Weldemeskel, and Berhanu Nigussie Worku. 2023a. "Strategies of Enhancing Students' Mathematics Perception and Self-Efficacy to Improve Their Mathematics Achievement." *Cogent Education* 10(2):1–20. doi: [10.1080/2331186X.2023.2285642](https://doi.org/10.1080/2331186X.2023.2285642).
- Shone, Enkosa Terefe, Fisseha Mikre Weldemeskel, and Berhanu Nigussie Worku. 2023b. "The Role of Students' Mathematics Perception and Self-Efficacy toward Their Mathematics Achievement." *Psychology in the Schools* 1–20. doi: [10.1002/pits.23033](https://doi.org/10.1002/pits.23033).
- Siregar, Rama Nida, Didi Suryadi, Sufyani Prabawanto, and Abdul Mujib. 2023. "Students' Mathematics Self-Efficacy in Learning Social Arithmetic Topic." *International Journal of Evaluation and Research in Education (IJERE)* 12(4):2176–85. doi: [10.11591/ijere.v12i4.25480](https://doi.org/10.11591/ijere.v12i4.25480).
- Siswono, Tatag Yuli Eko. 2011. "Level of Student's Creative Thinking in Classroom Mathematics." *Educational Research and Reviews* 6(7):548–53.
- Street, Karin Elisabeth Serlie, Lars-Erik Malmberg, and Stanislaw Schukajlow. 2024. "Students' Mathematics Self - Efficacy: A Scoping Review." *ZDM – Mathematics Education* 56:265–80. doi: [10.1007/s11858-024-01548-0](https://doi.org/10.1007/s11858-024-01548-0).
- Sugiyanto, F. N., M. Masykuri, and Muzzazinah. 2018. "Analysis of Senior High School Students' Creative Thinking Skills Profile in Klaten Regency." *International Conference on Science Education (ICoSEd)* 1006:1–5. doi: [10.1088/1742-6596/1006/1/012038](https://doi.org/10.1088/1742-6596/1006/1/012038).
- Triutami, Tabita Wahyu, D. Novitasari, R. Y. Tyaningsih, R. R. Elvierayani, and U. Lu'luilmaknun. 2021. "Visual-Spasial Intelligence Level of Junior High School Students: What Difficulties Are Experienced by the Students." *Journal of Physics: Conference Series* 1776(1):1–9. doi: [10.1088/1742-6596/1776/1/012033](https://doi.org/10.1088/1742-6596/1776/1/012033).
- UZUN, Zeynep Büşra, and Gülcan ÖZTÜRK. 2023. "Students' Spatial Abilities, Attitudes towards Geometry, and Van Hiele Geometric Thinking Levels." *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education* 17:666–94. doi: [10.17522/balikesirnef.1284875](https://doi.org/10.17522/balikesirnef.1284875).
- Yang, Y., Y. Maeda, and M. Gentry. 2024. "The Relationship between Mathematics Self-Efficacy and Mathematics Achievement: Multilevel Analysis with NAEP 2019." *Large-Scale Assessments in Education* 12(16):1–29. doi: <https://doi.org/10.1186/s40536-024-00204-z>.
- Yanuarto, Wanda Nugroho, and Agung Muhammad Iqbal. 2022. "Media Pembelajaran

Augmented Reality Untuk Meningkatkan Kemampuan Spasial Matematis Pada Konsep Geometri.” *Edumatica: Jurnal Pendidikan Matematika* 12(01):30–40. <https://doi.org/10.22437/edumatica.v12i01.17615>

Young, C. J., S. C. Levine, and Kelly S. Mix. 2018. “The Connection Between Spatial and Mathematical Ability Across Development.” *Frontiers in Psychology* 9(755):1–7. [doi: 10.3389/fpsyg.2018.00755](https://doi.org/10.3389/fpsyg.2018.00755).

Zakariya, Yusuf F. 2022. “Improving Students’ Mathematics Self-Efficacy: A Systematic Review of Intervention Studies.” *Frontiers in Psychology* 13:01–13. [doi: 10.3389/fpsyg.2022.986622](https://doi.org/10.3389/fpsyg.2022.986622).