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Exploring the Role of Geometry Understanding and Spatial Ability in Academic Achievement: The Moderating Effect of Self-confidence

Andi Aswani[1], Agustan S[2], Mukhlis[3]

[1] Universitas Muhammadiyah Makassar, Indonesia; andi.aswani@unismuh.ac.id
[2] Universitas Muhammadiyah Makassar, Indonesia; agustan@unismuh.ac.id
[3] Universitas Muhammadiyah Makassar, Indonesia; mukhlis@unismuh.ac.id

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ABSTRACT

This study investigates the impact of understanding geometry concepts, spatial ability, and self-confidence on student learning outcomes. Understanding geometry enhances mathematical logic, spatial ability strengthens spatial comprehension, and self-confidence boosts learning motivation. Collectively, these variables are crucial for improving student learning outcomes. The research employed an explanatory design, conducted in two elementary schools within the same cluster. A random sampling method selected samples from one class of an Elementary School in Panyikokkang with 21 students and another class with 23 students, resulting in a total of 44 students. Data collection instruments included a validated Self-Confidence questionnaire, Geometry Concept Understanding test, Spatial Ability test, and a Student Learning Outcomes test derived from daily quizzes on geometry topics. Data were analyzed using Inferential Statistical Analysis and Moderated Regression Analysis (MRA). The Moderated Regression Analysis (MRA) revealed that self-confidence acts as a quasi-moderator in the relationship between understanding geometry concepts and learning outcomes. Specifically, students with higher self-confidence showed a better understanding of geometry concepts, positively influencing their learning outcomes. However, self-confidence did not moderate the effect of spatial ability on learning outcomes. These findings highlight the importance of understanding geometry concepts in enhancing students' comprehension of geometry and developing spatial abilities at the elementary level. The results suggest that self-confidence plays a significant role in mediating the relationship between understanding geometry concepts and learning outcomes but not between spatial ability and learning outcomes. The study underscores the necessity for educators to focus on understanding geometry concepts and fostering self-confidence to design effective learning strategies that improve student achievement in mathematics, particularly in geometry.

Corresponding Author:
Andi Aswani
Universitas Muhammadiyah Makassar, Indonesia; andi.aswani@unismuh.ac.id

1. INTRODUCTION

Geometry has been taught from Phase A to Phase C in elementary school. In Phase A (grades I and II), students are introduced to basic geometric shapes and progress to a deeper understanding in subsequent grades (Inayah & Sugiarni, 2019). For students in Phase A, the demand for understanding geometric concepts is limited to shape classification, while higher grades incorporate topics such as finding the number of angles in a polygon, determining angle measures, calculating area, identifying nets, and computing volume (Inayah & Sugiarni, 2019). Therefore, to facilitate the understanding of geometric concepts in Phase C (grades V and VI), spatial abilities play a crucial role, as geometric material in Phase C encompasses more complex concepts. The spatial abilities possessed by students assist them in visualizing both two-dimensional and three-dimensional shapes (Afrilianto et al., 2018). This aligns with (Sihombing et al., 2021) perspective that spatial abilities help students imagine, determine, and construct in spatial or three-dimensional contexts. Generally, students with strong mathematical spatial abilities can create visual representations, think in three dimensions, and interpret images (Nuna et al., 2020).

Spatial abilities in geometric concepts are not new to students, as stated by (Maulani et al., 2022), who highlighted that geometry is fundamentally more accessible to students compared to other branches of mathematics. This is because geometric ideas, such as lines, planes, and spaces, are already known to students before they enter school. However, students with limited spatial abilities may face challenges in visualizing objects, which is a crucial aspect of understanding geometric concepts. As evident in the preliminary study conducted by the researcher among fifth-grade students at SD Panyikkokang I, a school in Gugus V, Panakukang District, Makassar City, on September 23, 2023, it was observed that questions numbered 3, 5, 7, and 9 were commonly answered incorrectly by students. Based on the examination of answers, 11 students answered question number 3 incorrectly, and 10 students answered question number 5 incorrectly. Students facing question number 3 need the ability to identify angles with specific measures. Conversely, students answering question number 5 are required to recognize the characteristics of a geometric shape that includes specific angles, such as right angles. This difficulty arises due to a lack of understanding of angle concepts and insufficient visualization skills to recognize geometric shapes from specific descriptions. Therefore, students need to be able to associate information about angle measures with the overall characteristics of geometric shapes. Thus, improving the understanding of angle concepts and developing visualization skills becomes crucial in overcoming these challenges.

Furthermore, for question number 7, there were 11 students who answered incorrectly and 14 students who answered incorrectly for question number 9. Questions 7 and 9 are designed to test the understanding of geometric concepts and spatial abilities of elementary school students, especially related to the concepts of symmetry and angles. Question number 7 illustrates a geometric shape that lacks rotational or reflective symmetry but has right angles and parallel sides. Students are tested to identify and understand the specific characteristics of this geometric shape. Meanwhile, question number 9 depicts a geometric shape with 4 reflective symmetries, 4 rotational symmetries, and right angles. Students are expected to recognize and understand the concepts of reflective symmetry, rotational symmetry, and right angles in this geometric shape.

The questions in question are as follows, providing further insight into the tasks and challenges faced by students in overcoming geometry and spatial ability exams at the elementary school level. Students encounter difficulties due to the expanded understanding of rotational symmetry, reflective symmetry, and right angles within a more complex context. Students need to comprehend that even if a shape lacks rotational or reflective symmetry, it can still have right angles and parallel sides, as explained in question number 7. Conversely, shapes with numerous rotational and reflective symmetries do not always have right angles, as illustrated in question number 9. The challenge of combining and understanding these concepts simultaneously can be a hurdle for students, reflecting difficulties in understanding geometric concepts and spatial abilities.

Hence, a shallow understanding of angle concepts and a lack of spatial abilities can be significant factors causing the majority of students to struggle in determining the types of angles in these four questions. The preliminary study conducted indicates that students' insufficient visual abilities can impact their understanding of the concepts of plane diagonals and space diagonals. As found in the study by (Rahman & Saputra, 2022), the subjects lacked complete visual abilities. The subjects still did not understand the difference between plane diagonals and space diagonals and were unsure about placing plane diagonals on planes and space diagonals in geometry. Insufficient visual abilities can lead to students' inability to clearly distinguish between these two concepts and create doubts in placing plane diagonals on planes and space diagonals in geometry.

This finding is consistent with previous research, as mentioned by (Anggo1, 2022), stating that self-confidence influences students' mathematics learning outcomes by 40%. Other researchers also show similar results, such as (Novita Sari, 2020), indicating that confidence has a significant impact on students' learning outcomes the purpose of this research is to:

1. To ascertain and describe the self-confidence possessed by students in moderating the influence of understanding geometric concepts on the academic achievement of fifth-grade students in Cluster V, Panakukkang Subdistrict, Makassar City.
2. To determine and describe the self-confidence variables held by students in moderating the influence of spatial abilities on the academic achievement of fifth-grade students in Cluster V, Panakukkang Subdistrict, Makassar City.

2. METHODS

The research design employed is explanatory research, conducted in two selected elementary schools within the cluster. The sampling technique utilized the random sampling method, and the two chosen schools are SD Panyikokkang I (class Va) with 21 students and SD Panyikokkang II (class Vb) with 23 students, resulting in a total sample size of 44 students. The data collection instruments consist of a Self-confidence questionnaire, Geometry Concept Understanding test, Spatial Ability test, and Academic Achievement test. Data analysis involves Inferential Statistical Analysis and Moderated Regression Analysis (MRA) (Creswell, 2015).

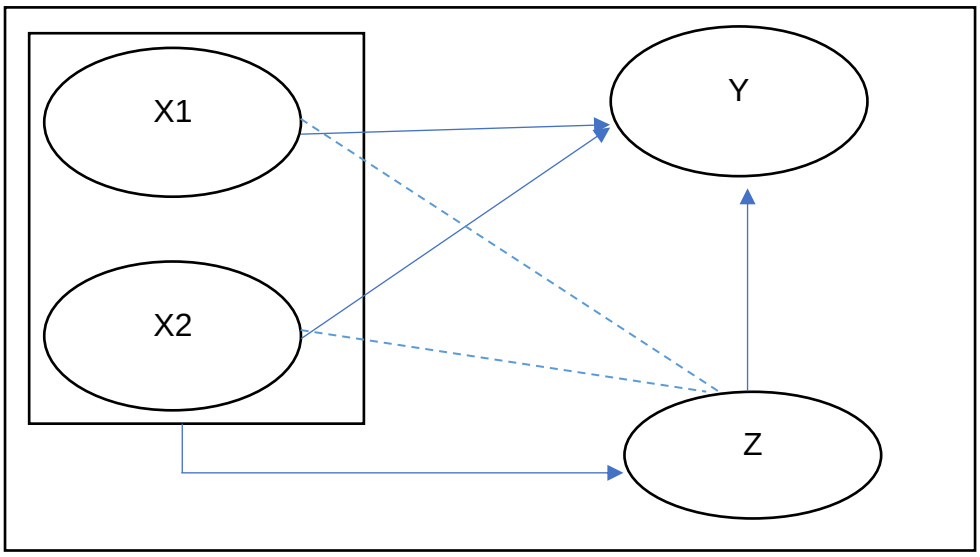

Figure 1. Research Design

3. FINDINGS AND DISCUSSION

3.1 Findings

Testing was conducted to examine the presence or absence of interactions between the variables of geometric concept understanding, spatial ability, and self-confidence with academic achievement. For testing the interaction between variables, if the significance value (p) > 0.05, it can be concluded that there is no interaction between variables. If the probability is <0.05, it can be concluded that there is an interaction between variables. The statistical hypotheses in this test are as follows:

H_0 : There is no interaction between self-confidence and the understanding of geometric concepts and spatial abilities in influencing academic achievement.

H_a : There is an interaction between self-confidence and the understanding of geometric concepts and spatial abilities that influences academic achievement.

The decision criteria are as follows:

1) If the significance value (p) is less than 0.05, then it is rejected.
2) If the significance value (p) is greater than 0.05, then it is accepted.

After the data processing, a summary of the hypothesis test results can be seen in the following Table 1.

Table 1. Variable Interaction Test

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.448	34.268		.071	.943
	Geometry Understanding	1.302	1.074	1.653	1.213	.233
	Spatial Ability	1.825	.739	3.161	2.471	.018
	Self-Confidence	.610	.774	.947	.788	.436
	Interaction between Geometric Concept Understanding & Self-Confidence	.045	.017	4.990	2.646	.012
	Interaction between Spatial Ability & Self-Confidence	.033	.023	3.434	1.447	.157

a. Dependent Variable: Hasil Belajar

Source: Author's data processing results, 2024

The significance value of the interaction between Self-confidence and understanding of geometry concepts obtained is 0.012. Since this significance value is smaller than α, the null hypothesis (H0) is rejected, or the alternative hypothesis (Ha) is accepted. Thus, it can be concluded that there is an interaction between Self-confidence and understanding of geometry concepts in influencing learning outcomes (0.012 < 0.05). The research hypothesis (Ha) is accepted. The summary of the results of the moderated regression analysis is presented in the following table.

Table 2. Summary of MRA Test Results

Variable	β	Sig
Constant	2.448	0.943
X1b2	0.307	0.014
Z	0.297	0.004
X1-Z (interaksi)	0.045	0.012< 0.05
Adj R-sq		0.446
F-Stat		7.431
Sig		0.000[b]

Source: Author's data processing results, 2024

The moderation variable on Self-Confidence and geometric concept understanding has a regression coefficient of 0.000 with a significant p-value (sig) of 0.012. This indicates that the moderation variable, Self-Confidence, has a positive effect on the influence of geometric concept understanding on academic achievement. In other words, the Self-Confidence variable strengthens the influence of geometric concept understanding on academic achievement. Further testing was conducted to show that b2 with a sig of 0.014 is significant, and b3 with a sig of 0.004 is also significant, meaning that Self-Confidence is a type of quasi-moderator variable.

Self-Confidence as a quasi-moderator variable indicates that, although there is a relationship between geometric concept understanding and students' academic achievement, the role of Self-Confidence in shaping this interaction is more complex or not entirely clear. In this case, Self-Confidence does not entirely modify the influence of geometric concept understanding on academic achievement significantly, as observed in stronger moderation variables.

The impact of the characteristics of this quasi-moderation variable can create several implications in the analysis and interpretation of data. Firstly, research results that present the relationship between geometric concept understanding and academic achievement do not entirely reflect the significant contribution of Self-Confidence in detailing the interaction between the two. Secondly, because Self-Confidence is a quasi-moderation variable, the interpretation and generalization of findings must be done cautiously. Further research may be needed to understand the context and conditions that can transform the role of Self-Confidence from quasi-moderation to a stronger or more significant moderation. These factors might include variations in the measurement methods of Self-Confidence, such as cultural differences, or individual student characteristics not fully covered in the study. Specifically, regarding its impact on the influence of geometric concept understanding on academic achievement, Self-Confidence as a quasi-moderation can suggest that, although it has the potential to influence this relationship, the factor of Self-Confidence is not able to significantly alter the level of influence of geometric concept understanding on students' academic achievement. Therefore, geometric concept understanding remains an important factor, and efforts to enhance Self-Confidence require a more specific and focused approach to significantly moderate this influence.

The MRA regression equation model is as follows:

$Y = a + B_1X_1 + B_2X_2 + \varepsilon$

$Y = a + b_1X_1 + b_2X_2 + b_3 X_1*Z + + \varepsilon$

$Y = 2.448 + 0.307X_1 + 0.114X_2 + 0.297X_1Z + 0.045X_1*Z \varepsilon$

Furthermore, the significance value for the interaction between Self-Confidence and spatial ability obtained is 0.157. Because this significance value is greater than α, H0 is accepted or Ha is rejected. Therefore, it can be concluded that there is no interaction between Self-Confidence and spatial ability in influencing academic achievement (0.157 > 0.05). The research hypothesis (Ha) is rejected.

3.2 Discussion

3.2.1 Self-confidence moderates the influence of geometric concept understanding on the academic achievement of fifth-grade students

This research explores the moderating effect of Self-Confidence on the relationship between geometric concept understanding and academic achievement of students. The data analysis results reveal a significance value for the interaction between Self-Confidence and geometric concept understanding of 0.012, which is statistically significant and smaller than the predetermined α value. Therefore, we can reject the null hypothesis (H0) and accept the alternative hypothesis (Ha) that there is a significant interaction between Self-Confidence and geometric concept understanding in influencing students' academic achievement. With a low significance value for the interaction, the

research findings indicate that Self-Confidence plays a significant moderating role in the relationship between geometric concept understanding and academic achievement. This implies that students' confidence levels can either strengthen or weaken the influence of geometric concept understanding on their academic achievement. This underscores the importance of considering psychological factors, such as confidence, in designing effective mathematics learning strategies.

As for the test results, it was found that self-confidence has a positive and significant impact on students' academic achievement, meaning that an increase in self-confidence will enhance their academic achievement. This can be observed from the analysis of the level of self-confidence by examining students' responses as follows:

a. High Self-Confidence

Based on the students' responses, the indicators of conceptual understanding can be achieved by students. Students can articulate the differences between cubes and rectangular prisms based on their shapes, and they are capable of assembling cubes and rectangular prisms. Similarly, regarding their properties, students identify fundamental differences between cubes and rectangular prisms. In the subsequent spatial ability test, students are already able to recognize that the nets depicted in the images are the nets of rectangular prisms.

b. Currently Self-Confidence

Based on the students' responses, it can be concluded that the indicators of conceptual understanding show progress, especially in comprehending the differences in shape between cubes and rectangular prisms. Students appear to be capable of distinguishing the physical structures of cubes and rectangular prisms. However, there is a need for further attention to understanding the properties of cubes and rectangular prisms, as there is a tendency for students to respond by highlighting their similarities. Therefore, the learning approach can be strengthened to provide a deeper understanding of the unique characteristics of each geometric shape. Additionally, in testing students' spatial abilities, errors were found in identifying the nets of rectangular prisms as the nets of cubes. This indicates confusion in the application of spatial concepts, and corrective measures need to be taken. Strengthening learning about the nets of cubes and rectangular prisms, along with more intensive exercises in recognizing and understanding their spatial structures, can help students overcome these errors and enhance their spatial abilities overall.

c. Low Self-Confidence

The students' responses indicate that their conceptual understanding of the differences between cubes and rectangular prisms has progressed, particularly in identifying the visual distinctions between the two geometric shapes. Nevertheless, it should be noted that when asked to explain the properties of cubes and rectangular prisms, students faced difficulties. The properties of cubes were answered with better accuracy compared to the properties of rectangular prisms, which were answered haphazardly. This suggests the need for additional focus on learning the properties of cubes and rectangular prisms to enable students to master the concepts comprehensively.

The spatial ability test also yielded interesting results, with students tending to answer haphazardly regarding the structures formed based on the provided nets. These errors reflect confusion in applying spatial concepts to practical situations. Therefore, a more in-depth learning approach is needed to assist students in recognizing and understanding how nets can form three-dimensional structures. Focused exercises on the relationship between nets and spatial shapes can provide better understanding and help students improve their spatial abilities.

Factors influencing students' academic achievements, aside from affective aspects, certainly involve other influencing factors. The author explored these factors by conducting interviews with participants based on their self-confidence levels. Participants with high, moderate, and low self-confidence categories expressed their opinions that:

Researcher: How do you feel when answering geometry test questions?
Student A with high self-confidence:

Answering geometry questions is easy for me. I can quickly see patterns and relationships between shapes. I enjoy working on geometry problems because I still remember the teacher's explanation from last week, and my mom also explained a bit before the test.

Student B with moderate self-confidence:
I find it difficult to answer geometry questions. That's why it takes me a long time to answer because I need a long time to understand the questions.

Student C with low self-confidence:
It's very difficult, especially the part about differentiation, both look the same to me. Especially the one that asks to draw, I don't know how to draw, even though I usually understand by looking at the pictures. But it's tough because the questions are also difficult, especially when they flip the pictures.

Based on the interview results, it is evident that students with high self-confidence find answering geometry questions easy. Their confidence in recognizing patterns and relationships between shapes can be attributed to the conceptual understanding provided by the teacher the previous week. Additionally, the extra explanation from the mother before the exam also contributed positively to understanding the material. The learning experience from the teacher and the support from parents seem to provide a strong foundation for this student to tackle geometry problems.

Students with moderate self-confidence express difficulty in answering geometry questions, possibly due to the length of time needed to comprehend the questions. They admit that it takes them a long time to realize what is being asked in the questions. The delay in responding to the questions may reflect challenges in understanding and applying geometric concepts. This student's openness provides clues about the need for a more in-depth learning approach and more supportive teaching methods.

Students with low self-confidence describe a high level of difficulty in answering geometry questions, especially those involving comparisons and drawings. These difficulties are compounded by the challenge of understanding the questions and the struggles with drawing. Their responses also highlight the perceived complexity of the questions as a challenge, especially in sections involving image reversals. Their explanations provide insights into the need for further assistance in understanding geometric concepts and drawing skills, as well as possibly considering more targeted question formulation.

This finding aligns with (Uron Hurit & Bin Frans, 2021) indicating a relationship between self-confidence anstudents' mathematics learning outcomes. It suggests that if students have high self-confidence, their mathematics learning outcomes are also high. Another supporting finding comes from (Inovasi & Matematika, 2021) , emphasizing the significant impact of an individual's self-confidence on problem-solving abilities. Individuals with high self-confidence greatly contribute to successful problem-solving tasks.

This conclusion is consistent with the hypotheses and research results conducted by (Hardianti1 et al., 2018; Hikmayani et al., 2023), revealing a mutually influential relationship between self-confidence and students' mathematical understanding abilities. It implies that students obtaining high scores in post-tests of mathematical understanding also exhibit high self-confidence, and vice versa for those with low scores. This aligns with the views of (Rizkiana et al., 2019; Yurmalia & Hasanah, 2021) regarding self-confidence as a crucial aspect of human personality that plays a vital role in actualizing one's potential or abilities. Acceptance of the research hypotheses provides a foundation for the development of a more holistic learning method, emphasizing not only the understanding of geometric concepts but also giving special attention to the enhancement of students' self-confidence.

3.2.2 Self-confidence moderates the influence of spatial abilities on the learning outcomes of fifth-grade students

The findings suggest that self-confidence does not play a significant role in altering the relationship between spatial abilities and the academic achievement of students. In other words, spatial abilities continue to have a consistent and direct impact on learning outcomes, regardless of the levels of self-confidence among students. This insight is particularly relevant for understanding the factors that influence mathematics learning outcomes among fifth-grade students. It emphasizes that while self-confidence is an important trait, it does not necessarily change how spatial skills contribute to students' performance in academic tasks, particularly in subjects like mathematics that heavily rely on spatial reasoning.

As a result, educators and policymakers in Gugus V, Panakukkang Subdistrict, Makassar City, should recognize that boosting self-confidence might not directly enhance the impact of spatial abilities on academic achievement. Instead, educational strategies could be better targeted towards directly strengthening students' spatial abilities to improve their learning outcomes. Focusing on activities and teaching methods that enhance spatial reasoning, such as problem-solving tasks, geometry exercises, and spatial visualization activities, could more effectively boost student performance in mathematics. This targeted approach could lead to more precise and successful educational interventions, ultimately supporting better academic results for students in this region.

4. CONCLUSION

The analysis concludes that there is a significant interaction between self-confidence and understanding of geometric concepts in influencing students' learning outcomes. The results demonstrate that self-confidence acts as a quasi-moderator, as indicated by the significance of b2 and b3 in the analysis, meaning that students with higher self-confidence tend to have a better grasp of geometric concepts, positively impacting their academic performance. However, self-confidence does not serve as a moderator in the relationship between spatial abilities and learning outcomes, suggesting that spatial skills impact learning independently of self-confidence levels. This study has some limitations, such as a focus on a specific student population and a limited scope of variables, which may affect the generalizability of the findings. Future research should explore other potential moderators or mediators, such as motivation or teaching methods, and examine a broader range of student groups to better understand the complex dynamics between self-confidence, spatial ability, and academic achievement.

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