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Measuring the Mathematical Representation Ability of Vocational High School Students in Solving Geometry Problems

Jumiarti[1], Sukmawati[2], Muhammad Muzaini[3]
[1, 2, 3] Department of Mathematics Education, Postgraduate, University of Muhammadiyah Makassar, Indonesia

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ABSTRACT

The intent of this study is to measure and describe the mathematical representation ability of vocational high school students in solving geometry problems. Using a descriptive research design with a qualitative approach, this study evaluates three primary forms of representation: visual, symbolic, and verbal. The subjects were grade XI students at Vocational School 3 Pinrang, selected to represent different levels of visual-spatial intelligence to see how it affects their representational performance. Data was collected through mathematical representation tests and semi-structured interviews. The analysis followed the stages of data reduction, data display, and conclusion drawing. The findings indicate that students' mathematical representation abilities vary significantly. High-capacity students can present geometric problems visually, interpret symbols, and construct mathematical models, although they still struggle with verbalizing conclusions. In contrast, students with low ability are primarily limited to basic image-based tasks. The results show that while visual-spatial intelligence correlates with better representational skills, overall proficiency in solving complex geometry tasks remains low across the subjects. This measurement provides a baseline for developing targeted instructional strategies in vocational geometry education.

Corresponding Author:

Muhammad Muzaini,
Department of Mathematics Education, Postgraduate, University of Muhammadiyah Makassar, Indonesia
Email: muhammadmuzaini@unismuh.ac.id

1. INTRODUCTION

Education helps develop potential, talents, and abilities and creates societally acceptable individuals. Education helps build potential, but talent development requires environmental assistance (Darling-Hammond et al., 2020). Education shapes intellectual, social, and character development. Mathematics helps kids think clearly and analytically (Durand-Guerrier, 2020).

The value of scientific analysis and logic in math and science (Cellucci, 2013; Hoffmann & Even, 2024). Mathematical reasoning is rational. As logic develops, its problems get more complicated and demand a better analysis structure (Geiger et al., 2023; Jablonka, 2020). Math skills gained early on improve academic ranks and cognitive ability, according to studies. Research shows that early mathematical skills influence non-mathematical courses like science and literacy through high school. Math in vocational education, especially in secondary schools, develops students' academic and work capabilities. We teach math to equip pupils with basic math literacy.

The emphasis on similarities makes even more quantitative abilities necessary for vocational high school pupils to use their theoretical knowledge. Math in vocational education may also foster critical thinking (Dalby & Noyes, 2016; Hermans et al., 2024; Sumandya & Widana, 2022). For instance, Yoto et al. (2024) and Zirkle (2017) found that vocational schools must overhaul human resources and mathematics curriculum to effectively initiate these processes.

Unlike high schools, vocational high schools are distinct (Nika, 2025). Vocational high schools differ from high schools. This variation makes vocational school math learning different from high school math. Professional education institutes' mathematics teaching materials vary for each competency program due to various needs. Vocational schools teach math to promote an adaptable attitude (Glerum et al., 2020). Students at vocational high school must adapt to social and workplace changes and maximize their potential (Indrawati & Kuncoro, 2021; Jaedun et al., 2024).

Students at vocational school should have representational skills. Students may visualize and articulate mathematical concepts using visuals, symbols, and mathematical notation (Bolden et al., 2015; Putra, 2023). Students need this skill to grasp and solve complicated, abstract spatial geometry problems. NCTM wrote that learning mathematics requires problem-solving, communication, reasoning, connection, and representation skills. Representation involves expressing concepts using words, symbols, photos, diagrams, models, or physical objects (Duval, 2017; Hebert & Powell, 2016). Students need mathematical representation to understand abstract math topics. Students can better understand concepts via graphs, diagrams, symbols, or descriptions. Jitendra et al. (2016) agreed that representations help students learn and organize mathematical concepts.

This study also shows that representation skills greatly affect pupils' math problem-solving. Hoogland et al. (2018) observed that students who are good at using multiple representations are more likely to solve problems. Representations assist students in understanding concepts and gaining confidence in solving issues, according to Abramovich et al. (2019). Bicer (2021) also found that mastering diagrams and symbols helps pupils think more deeply and creatively in math. This helps individuals grasp concepts and solve harder difficulties.

Visual-spatial intelligence—the ability to perceive and use visual and spatial information—is closely related to mathematical representation skills (Anugrah & Hidayat, 2023; Li et al., 2025). Visual-spatial intelligence helps students visualize mathematical concepts and understand graphs, charts, and other mathematical representations (del Cerro Velázquez & Morales Méndez, 2021). Perspective, geometric shapes, integrating spatial concepts with numbers, and mental picture transformation are needed for visual-spatial intelligence (Atit et al., 2022). Learning math involves these skills. Visual-spatial intelligence involves understanding, manipulating, and visualizing three-dimensional objects and relationships. This ability is essential to comprehending geometry since it applies to flat shapes and three-dimensional objects that require perspective and projection. Geometry learners with high visual-spatial intelligence find it easier to understand shapes, angles, and dimensions (Goldsmith et al., 2016; Hendradi, 2021). Visual-spatial intelligence involves understanding and remembering spatial relationships between objects (Weimer et al., 2024). Aziz et al. (2020) found that visual-spatial intelligence is essential for geometry problem solving. Students with high visual-spatial intelligence may use visual representations to understand and solve geometric problems better than those with lesser intelligence.

Students with high visual-spatial intelligence may solve spatial geometry issues utilizing symbolic and visual mathematical representations, according to several research studies (Hendradi, 2021). Studies show that visual representations improve geometry problem-solving (Van Garderen & Montague, 2003). Understanding visual-spatial intelligence and mathematical representation is crucial to constructing geometry learning strategies for kids. This study will help establish better spatial geometry teaching methods for vocational high school students.

In a preliminary investigation, the author thought that vocational high school students were unable to express difficulties verbally or in pictorial form to find solutions. This prevented students from answering symbolic mathematical questions. More research is needed to determine how successfully students can use mathematical representations to solve issues, especially with spatial geometry content they studied based on their visual-spatial intelligence.

According to Asyrofi and Junaedi (2016), visual-spatial intelligence hinders pupils' mathematical representation ability. Hindal (2014) defines visual-spatial intelligence as imaging, pattern searching, problem solving, and conceptualization. Features of imagination: Students with high visual-spatial intelligence learn better by seeing than hearing, which may impair arithmetic performance. Math issues are easier for creative students.

Students with strong visual-spatial intelligence have varied abilities, chosen uncommon solutions, and have multiple problem-solving strategies. These students are likely to think holistically, which aids learning. High-visual-spatial-intelligence students may relate a problem to other knowledge and understand a notion holistically (Goldsmith et al., 2016; Hendradi, 2021). This aptitude helps kids understand math, especially geometry. Many kids still misunderstand math.

Research on mathematical representation ability has been widely conducted at the junior high or senior high school level (Hariadi et al., 2019; Lutfi & Juandi, 2023; Putra et al., 2020; Sari et al., 2023). However, this article offers several novel aspects, namely (1) the specific context of vocational high school students: In contrast to senior high school students who focus on theory, this study highlights how vocational high school students—who have a higher visual-spatial orientation due to their practical background—construct their mathematical representations. (2) Integration of Applied Geometry Problems: The measurement instrument in this article does not only use

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abstract geometry problems but also integrates contexts relevant to the vocational world (for example, spatial interpretation of machine components or building structures), thus providing a real picture of students' work readiness from a cognitive perspective. (3) Multi-Indicator Analysis: This article evaluates three representation indicators (visual, mathematical expressions, and written text) simultaneously to see the dominant tendencies of vocational high school students in solving spatial problems, which are rarely discussed in depth in previous vocational education literature.

After reviewing the topic, preliminary investigations, and relevant research, the researcher wishes to know how vocational high school students use mathematical representation to solve spatial geometry problems. This study describes how to measure and describe the mathematical representation ability of vocational high school students in solving geometry problems. This information is crucial to understanding how pupils learn math using visual-spatial skills.

2. METHOD

This is qualitative descriptive study. Qualitative research uses natural settings and several ways to interpret events. The mathematical representation of vocational high school pupils answering space geometry issues will be determined by their visual-spatial intelligence. This research will be done at public vocational school 3 Pinrang, which comprises 25 classrooms, including 199-student class XI. The data for this study comes from class XI students at public vocational school 3 Pinrang and their math teachers. Purposive sampling was utilized to choose study participants.

This study included vocational high school students with variable visual-spatial intelligence. The researcher selected high- and low-visual-spatial intelligence pupils. This experiment examines if visual-spatial intelligence affects mathematical representation in students. The researcher's information needs determine subject selection, thus it must be done carefully to meet study goals. Table 1 classifies pupils' visual-spatial intelligence.

Table 1. Visual Spatial Intelligence Category (Research subject)

No	Interval	Visual spatial intelligence category
1	$X > 75 + SD$	High ability in visual-spatial intelligence
2	$X \leq 75 - SD$	High ability in visual-spatial intelligence

The data collection techniques for this study were tests and interviews.

1. Tests

Visual-spatial intelligence tests were administered using standard instruments in this investigation. The instrument tests a person's capacity to interpret, analyze, and use images or space. This test involves identifying patterns, spinning mental shapes, picturing objects, and solving image or geometric shape issues. This standard instrument lets us accurately assess kids' visual-spatial intelligence. Based on the indicators, we also use the student mathematical representation test to evaluate students' representation skills. Student mathematical representation skills in space geometry problems are tested. Figure 1 shows the issue.

Given block ABCD.EFGH has a length of AB = 3 cm, BC = 4 cm, and CG = 24 cm. Point P represents the midpoint of AC, and Q is in the middle of CG. Determine the distance from point A to Q!

Figure 1. Geometry Problems

2. Interviews

To better understand vocational high school students' visual-spatial intelligence in solving spatial geometry problems, this study will interview them. This study will use semi-structured interviews. Students will be interviewed after completing a written test on spatial geometry mathematical representation. This interview clarifies students' written test responses.

We analyzed and reported field research data. The data analysis procedure includes reduction, display, and conclusion/verification. Our study used method and source triangulation, getting method triangulation from tests and interviews. Source triangulation came from teacher and topic interviews.

3. RESULTS AND DISCUSSION

Of the 199 grade XI pupils who took the visual-spatial IQ test, 25 (15 male and 10 female) scored > 75. Of the 25 candidates who fit the criteria, we chose one with high visual-spatial intelligence. Furthermore, 174 students—100 males and 74 females—scored below 75. We chose a low-visual-spatial intelligence candidate. To learn more about how students with different levels of visual-spatial intelligence can use math to solve space geometry problems, the following students were interviewed: SH (high) and SL (low).

Space geometry problems solving process of SH

Figure 1 is a quotation of interview results carried out by SH on mathematical representation ability.

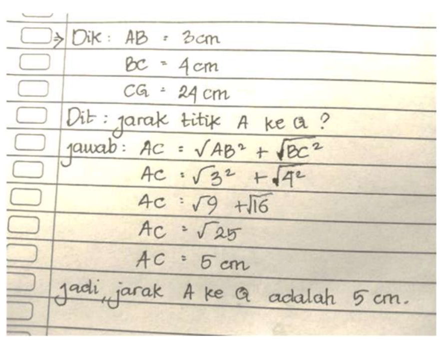

Figure 2. Problem Solving Geometry Activities by SH

SH understands the given geometry problem and provides detailed information, including what is known and asked. Excerpts from interviews by SH on representation ability are as follows:

P: Good morning, thank you for agreeing to participate in this interview. I would like to discuss your representation ability in solving geometry problems.
SH: Good morning, Ma'am. I'm ready.
P: Okay. Let's start with the following problem: Given block ABCD.EFGH has a length of AB = 3 cm, BC = 4 cm, and CG = 24 cm. Point P represents the midpoint of AC, and Q is in the middle of CG. Determine the distance from point A to Q!
SH: Hmm... I think I can use the formula for the distance between a point and a line in 3D space with the Pythagorean theorem formula.
P: Good! Please explain how you use the formula to solve this problem.
SH: Okay. I will use the Pythagorean theorem formula: $a^2 + b^2 = C^2$*, where c is the length of the hypotenuse, and a and b are the lengths of the two short sides.*
P: Good! And how do you calculate the distance from point A to Q?
SH: I will calculate the distance AC by squaring the length of AB and the length of BC.
P: Good! How do you calculate the distance from point A to Q after you square the lengths of AB and BC?
SH: I will calculate the distance using the formula I mentioned earlier. However, I modified it to AC = $\sqrt{(AB + BC)^2}$.
P: Good! Thank you. You have shown good representation skills in solving geometry problems, but there are misconceptions about problem solving that are done.

Visual Representation of SH

Quotations from the interview by SH regarding the visual representation ability are as follows:

P: Good morning. I would like to discuss your visual representation skills in solving geometry problems.
SH: Good morning, ma'am. I am ready to be interviewed.
P: Okay. How would you approach a geometry problem?
SH: Hmm... I read the problem first to determine the information, then tried to draw the block and show the distance from point A to Q.
P: Okay! Please explain what you drew and how you showed the distance from point A to Q.
SH: Yes, ma'am. I drew the block ABCD.EFGH and identified the known and requested items in the problem. I also showed the line and drew the distance from point A to Q.
P: Do you have difficulty drawing the block ABCD.EFGH with the information known in the problem?
SH: Yes, ma'am. I have difficulty drawing the line (distance in a geometric figure).
P: Then how do you calculate the distance from point A to Q if you have difficulty drawing the block ABCD.EFGH, as well as the information known?
SH: I will use the Pythagorean theorem formula: $a^2 + b^2 = C^2$*, where c is the length of the hypotenuse, and a and b are the lengths of the two short sides. I immediately solved the problem without using a picture.*
P: Okay! Thank you.

SH reads the geometry issue to determine what is known and asked without writing it down. SH also understands the geometry difficulty because he can explain the math problem. SH struggles to illustrate geometric problems. SH also solves problems without visuals. High spatial intelligence students can calculate geometry correctly and observe geometric correlations (Riastuti et al., 2017). Students with superior spatial intelligence understand geometry better (Hendradi, 2021).

Symbolic Representation of SH

Quotations from the interview by SH regarding the symbolic representation ability are as follows:

P: Good morning. Thank you for agreeing to participate in this interview.
SH: Good morning, Ma'am.
P: Okay. Do you understand the following question? Given block ABCD.EFGH has a length of AB = 3 cm, BC = 4 cm, and CG = 24 cm. Point P represents the midpoint of AC, and Q is in the middle of CG. Determine the distance from point A to Q!
SH: Yes, Ma'am. I understand the question and the information I known and asked.
P: How do you determine the distance from point A to Q?
SH: Hmm... I use the Pythagorean theorem formula: $a^2 + b^2 = C^2$*, where c is the length of the hypotenuse, and a and b are the lengths of the two short sides.*
P: Okay! Please explain how you use the formula to solve this question.
SH: I will calculate the distance AC by squaring the length of AB and the length of BC. Then, I will calculate the distance using the formula.
P: Good! How do you calculate the distance from point A to Q after you square the lengths of AB and BC?
SH: I will calculate the distance using the formula I mentioned earlier. However, I modified it to AC = $\sqrt{(AB + BC})^2$.
P: Do you have difficulty using the formula mentioned earlier?
SH: Yes, madam. I am having trouble utilizing the modified formula, as it appears that my response is inaccurate.
P: Why do you have difficulty?
SH: I believe that the distance from point A to Q is equivalent to the distance from point A to C.
P: Okay! Thank you.

SH understands the geometry problem by determining known and asked information. SH also comprehends the problem's symbols. SH creates geometric problem-solving models. SH struggles with the geometry problem model. The Figure 2 answers show this. High spatial intelligence students tackle constructive problems by recognizing traits and applying visual representations (Aziz et al., 2020; Hendradi, 2021).

Verbal Representation of SH

Quotations from the interview by SH regarding the verbal representation ability are as follows:

P: Good morning. Thank you for agreeing to join this interview. I would like to discuss your verbal representation skills in solving geometry problems.
SH: Good morning, Ma'am. I'm ready.
P: Okay. Here is a geometry problem: Given block ABCD.EFGH has a length of AB = 3 cm, BC = 4 cm, and CG = 24 cm. Point P represents the midpoint of AC, and Q is in the middle of CG. Determine the distance from point A to Q!
SH: Hmm... I will explain the steps I took to solve this problem. First, I used the Pythagorean theorem formula: $a^2 + b^2 = C^2$*. Next, apply the modified formula. Thereafter, calculate the distance AC by squaring the length of AB and the length of BC.*
P: Okay! Please explain more about the steps you took.
SH: Okay. Once I have squared the lengths of AB and BC, I will proceed. I will calculate the sum of the squares of the lengths of AB and BC. Then the results of the square of the lengths of AB and AC; I do the addition, and then the result of the addition is squared. The result of the square root is the distance from point A to Q.

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P: Okay! How do you ensure that the answer obtained is correct?
SH: I make sure that I use the correct formula.
P: Okay! What conclusion do you get from this geometry problem?
SH: I don't know, ma'am.
P: Okay! Thank you.

SH uses modified Pythagorean theorem to teach geometry problem solutions. By ensuring the formula used to solve the problem is valid, SH produces a verbal problem situation. However, SH struggles to make inferences regarding the geometry problem's solution. Figure 2 shows SH doesn't take any conclusions from the answer. Students with good spatial intelligence can write about challenges. Students who can manipulate verbal translations are good problem-solvers (Anwar & Rahmawati, 2017; Lee & Hwang, 2022).

Space geometry problems solving process of SL

Figure 3 is a quotation of interview results carried out by SL on mathematical representation ability.

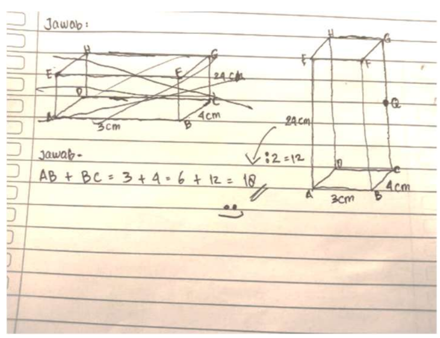

Figure 3. Problem Solving Geometry Activities by SL

SL understands the geometric problem given but does not provide detailed information, including what is known and asked. Excerpts from SL's interview regarding representational abilities are as follows:

P: Good morning, thank you for agreeing to take part in this interview.
SL: Good morning; yes, ma'am.
P: OK. Here is a geometry problem: Given block ABCD.EFGH has a length of AB = 3 cm, BC = 4 cm, and CG = 24 cm. Point P represents the midpoint of AC, and Q is in the middle of CG. Determine the distance from point A to Q!
SL: Yes, ma'am. Firstly, I drew the known information about the problem. Then I calculated the length of AB, the length of BC, and half the length of CG (length of CQ).
P: OK! Please explain how to calculate the distance from point A to Q.
SL: Yes, ma'am. First, I divided the length of AE, which is 24 cm, into 12 cm. Thereafter, I added up the length of AB, the length of BC, and the length of CQ.
P: OK! And thereafter, what else did you do?
SL: Nothing, ma'am. This is because you have already solved the given geometry problem.
P: Okay! Thank you.

Visual Representation of SL

Quotations from the interview by SL regarding the visual representation ability are as follows:

P: Good morning.
SL: Good morning, Ma'am.
P: Okay. What did you do after being given a problem?
SL: I tried to draw the block and show the distance from point A to Q.
P: Okay! Please explain the drawing and how you depicted the distance from point A to Q.
SL: Yes, Ma'am. I drew cuboid ABCD.EFGH and determined the known things in the problem.
P: Did you have difficulty drawing cuboid ABCD.EFGH with the information known in the problem?
SL: Yes, Ma'am. I had difficulty drawing cuboid ABCD. EFGH was created using the information provided in the problem.
P: If you had difficulty, then how did you calculate the distance from point A to Q?
SL: I calculated the length of AB, the length of BC, and half the length of CG (the length of CQ). I immediately solved the problem using the drawing of cuboid ABCD.EFGH that I made.
P: Okay! Thank you.

SL drew the geometry issue to find the associated information without writing down the known and asked information. SL also understands geometry difficulties because he can draw a cuboid ABCD.EFGH, as shown in Figure 3. However, SL struggles with picture puzzles and geometry formulas. SL uses drawings to solve difficulties. Low spatial intelligence students struggle with visual representation. Students with limited spatial abilities lack geometric skills (Riastuti et al., 2017).

Symbolic Representation of SL

Quotations from the interview by SL regarding the symbolic representation ability are as follows:

P: Good morning. Thank you for agreeing to take part in this interview.
SL: Good morning, ma'am.
P: OK. Do you understand the questions I asked you before?
SL: A little less, ma'am.
P: If so, how were you able to determine the distance from point A to Q?
SL: I added up the length of AB, the length of BC, and half the length of CG (length of CQ) based on the drawing I had made.
P: OK! Could you please explain how you solved this problem?
SL: After adding the length of AB, the length of BC, and half of the length of CG (the length of CQ). Immediately I get the distance between points A and Q.
P: OK! Do you have difficulty determining the formula to use in solving the given problem?
SL: Yes, ma'am, I have difficulty using formulas because I don't understand this geometry problem a little.
P: Why are you having trouble?
SL: Because I don't understand what formula is used to determine the distance between points.
P: OK! Thank you.

SL did not understand the geometry problem, even what was known and asked, but could provide the image. Additionally, SL did not grasp the problem symbols. Geometry problem-solving models were similarly unsuccessful in SL. The geometry problem model was also problematic for SL. The Figure 3 responses show that SL used no formulas. Visual representation is minimal for poor visual spatial intelligence students. Low spatial intelligence students employ verbal representation, but their explanations are inadequate or do not describe the situation.

Visual Representation of SL

Quotations from the interview by SL regarding the verbal representation ability are as follows:

P: Good morning.
SL: Good morning, ma'am.
p: OK. What did you do to solve the problem given?
SL: First, I first drew the block ABCD.EFGH. Thereafter, determine the length of AB, the length of BC, and half the length of CG (the length of CQ) based on the drawing that I have made.
P: OK! So, what are the next steps you take?
SL: After determining the length of AB, the length of BC, and half the length of CG (the length of CQ). Then I added up the lengths of AB, BC, and CQ. The result of the sum is the distance from point A to Q.
P: How do you ensure that the answers you get are correct?
SL: I'm not sure about my answer, ma'am, because I used an incorrect formula.
P: OK! What conclusion do you draw from this geometry problem?
SL: No, ma'am.
P: OK! Thank you.

SL can describe geometry problems but uses the wrong mathematical formula or model. SL also did not verbally establish a problem circumstance or validate the formula utilized to solve it. SL also struggled to draw implications from geometry problem answers. Low spatial intelligence students are marginally better at mathematical expression representation than visual and verbal. Anwar and Rahmawati (2017) say students that employ symbolic representation succeed.

This study's data analysis identifies three categories of students' representation abilities in geometry issues based on their visual-spatial intelligence: visual, symbolic, and verbal representation abilities. Table 2 delineates the characteristics of each kind according to the degree of visual-spatial intelligence.

Table 2. Characteristics of Students (High and Low) in Solving Geometric Problems

Types of Representation Ability	High Level of Visual-Spatial Intelligence	Low Level of Visual-Spatial Intelligence
Visual	Presenting geometric problems in pictorial form and solving the problem does not involve images.	Does not present geometric problems in image form and solving problems involving images.
Symbolic	Understanding a symbol from a mathematical model, creating a mathematical model, and not solving problems using a	Not understanding a symbol from a mathematical model, not making a mathematical model, and not solving

Types of Representation Ability	High Level of Visual-Spatial Intelligence	Low Level of Visual-Spatial Intelligence
	mathematical model are the three key concepts.	problems using a mathematical model
Verbal	Create a problem situation in verbal form and do not draw conclusions about the answer.	Do not create problem situations in verbal form and do not draw conclusions about answers.

Table 2 indicates disparities in the representational capabilities of pupils possessing high visual-spatial intelligence compared to those with poor visual-spatial intelligence. The disparities in SH and SL's visual, symbolic, and representational competencies in resolving geometry issues are readily evident. In terms of visual representation, SH can depict geometric problems but does not resolve issues related to visuals. In terms of symbolic representation, SH understands symbols from mathematical models and builds mathematical models, but it doesn't use them to solve problems. Furthermore, in terms of verbal representation, SH can formulate a problem scenario verbally but refrains from drawing inferences about the solution. Moreover, among the three dimensions of representational capabilities, SL is solely proficient in resolving issues related to images.

The results demonstrate variations in students' representational capabilities contingent upon their level of visual-spatial intelligence when addressing geometry difficulties. This aligns with a study by Hendradi (2021), indicating that students with elevated spatial intelligence achieve superior geometry learning outcomes. This also pertains to the representational skills exhibited by students with elevated spatial intelligence. Students possessing elevated spatial intelligence address constructive challenges by identifying attributes through visual representations to articulate problems. Students possessing elevated spatial intelligence can articulate difficulties using written language. Students proficient in translating verbal representations possess exceptional problem-solving abilities (Lee & Hwang, 2022). Conversely, students with diminished visual-spatial intelligence utilize minimal or no visual representation. Students with limited spatial intelligence utilize verbal representation; nonetheless, their explanations are inadequate and fail to depict the provided world accurately. Nonetheless, pupils with low spatial intelligence effectively utilize mathematical expression representation, and their solutions often employ this style as well. Students with diminished spatial intelligence have challenges in employing visual representation skills. Students with deficient spatial abilities lack geometric capabilities (Riastuti et al., 2017).

Mathematical representation ability refers to the capacity to articulate mathematical concepts across diverse modalities. This skill is a fundamental mathematical competency essential for students to acquire (Abramovich et al., 2019; Hoogland et al., 2018; Niss & Højgaard, 2019). The capacity for representation aids pupils in comprehending concepts, articulating ideas, and devising solutions to mathematical challenges. Consequently, the results indicate that pupils possessing a high degree of visual-spatial intelligence outperform those with a low degree of visual-spatial intelligence at each stage of problem-solving. Moreover, the capacity for representation differs among students, with this study yielding greater insights through analysis and debate than the initial research conducted by Goldsmith et al. (2016).

4. CONCLUSION

The study's results reveal disparities in students' representation skills across visual, symbolic, and verbal modalities. Students possessing elevated visual-spatial intelligence participate in activities like the visual presentation of geometry problems, interpretation of symbols from mathematical models, construction of mathematical models, and verbal formulation of problem scenarios. Students with low-level visual-spatial intelligence are solely capable of resolving image-based difficulties. Furthermore, the study's results revealed that both individuals were incapable of performing activities, such as resolving image-related problems, utilizing mathematical models to address challenges, and drawing conclusions from the solutions. Additionally, this study demonstrates that students have been unable to fully utilize all facets of representational ability, encompassing visual, symbolic, and verbal forms. Consequently, it is imperative to undertake additional qualitative research across diverse grade levels, employing a range of topics. The enhancement of analytical outcomes requires validation through alternative problems. The present study introduces a novel method for delineating students' evolving representational skills.

The findings of this study indicate various implications for the enhancement of students' broader representation skills. The findings and implications offer numerous practical considerations for the design of geometric problem-solving exercises within educational programs, especially for mathematics educators. This study is constrained to observational data, resulting in a small-scale investigation including two students with varying degrees of visual-spatial intelligence, selected from a cohort of 199 participants at a single vocational high school.

REFERENCES

Abramovich, S., Grinshpan, A. Z., & Milligan, D. L. (2019). Teaching mathematics through concept motivation and action learning. *Education Research International*, *2019*(1), 3745406. https://doi.org/10.1155/2019/3745406

Anugrah, D., & Hidayat, R. (2023). Mathematical representation ability of students with moderate visual spatial intelligence in solving solid figure problems. *Mathline: Jurnal Matematika Dan Pendidikan Matematika*, *8*(2), 677–690. https://doi.org/10.31943/mathline.v8i2.433

Anwar, R. B., & Rahmawati, D. (2017). Symbolic and Verbal Representation Process of Student in Solving Mathematics Problem Based Polya's Stages. *International Education Studies*, *10*(10), 20–28. https://eric.ed.gov/?id=EJ1156292

Asyrofi, M. A. M., & Junaedi, I. (2016). Kemampuan representasi matematis ditinjau dari multiple intellingence pada pembelajaran hybrid learning berbasis konstruktivisme. *Unnes Journal of Mathematics Education Research*, *5*(1), 32–39. https://journal.unnes.ac.id/sju/ujmer/article/view/12914/7048

Atit, K., Power, J. R., Pigott, T., Lee, J., Geer, E. A., Uttal, D. H., Ganley, C. M., & Sorby, S. A. (2022). Examining the relations between spatial skills and mathematical performance: A meta-analysis. *Psychonomic Bulletin & Review*, *29*(3), 699–720. https://doi.org/10.3758/s13423-021-02012-w

Aziz, J. A., Juniati, D., & Wijayanti, P. (2020). Students' Reasoning With Logical Mathematical and Visual Spatial Intelligence in Geometry Problem Solving. *Proceedings of the International Joint Conference on Science and Engineering (IJCSE 2020)*, 203–207. https://doi.org/10.2991/aer.k.201124.038

Bicer, A. (2021). Multiple representations and mathematical creativity. *Thinking Skills and Creativity*, *42*, 100960. https://doi.org/10.1016/j.tsc.2021.100960

Bolden, D., Barmby, P., Raine, S., & Gardner, M. (2015). How young children view mathematical representations: a study using eye-tracking technology. *Educational Research*, *57*(1), 59–79. https://doi.org/10.1080/00131881.2014.983718

Cellucci, C. (2013). *Rethinking Logic: Logic in Relation to Mathematics, Evolution, and Method* (Vol. 1). Springer Netherlands. https://doi.org/10.1007/978-94-007-6091-2

Dalby, D., & Noyes, A. (2016). Locating mathematics within post-16 vocational education in England. *Journal of Vocational Education & Training*, *68*(1), 70–86. https://doi.org/10.1080/13636820.2015.1110828

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, *24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

del Cerro Velázquez, F., & Morales Méndez, G. (2021). Application in Augmented Reality for Learning Mathematical Functions: A Study for the Development of Spatial Intelligence in Secondary Education Students. *Mathematics*, *9*(4), 369. https://doi.org/10.3390/math9040369

Durand-Guerrier, V. (2020). Logic in Mathematics Education. In *Encyclopedia of Mathematics Education* (pp. 478–481). Springer International Publishing. https://doi.org/10.1007/978-3-030-15789-0_92

Duval, R. (2017). *Understanding the Mathematical Way of Thinking – The Registers of Semiotic Representations*. Springer International Publishing. https://doi.org/10.1007/978-3-319-56910-9

Geiger, V., Gal, I., & Graven, M. (2023). The connections between citizenship education and mathematics education. *ZDM – Mathematics Education*, *55*(5), 923–940. https://doi.org/10.1007/s11858-023-01521-3

Glerum, J., Loyens, S. M. M., & Rikers, R. M. J. P. (2020). Mind your mindset. An empirical study of mindset in secondary vocational education and training. *Educational Studies*, *46*(3), 273–281. https://doi.org/10.1080/03055698.2019.1573658

Goldsmith, L. T., Hetland, L., Hoyle, C., & Winner, E. (2016). Visual-spatial thinking in geometry and the visual arts. *Psychology of Aesthetics, Creativity, and the Arts*, *10*(1), 56–71. https://doi.org/10.1037/aca0000027

Hariadi, M. H., Wilujeng, I., & Kuswanto, H. (2019). Improving mathematical representation ability of student's senior high school by inquiry training model with google classroom. In *Journal of Physics: Conference Series* (Vol. 1233, No. 1, p. 012043). IOP Publishing. https://doi.org/10.1088/1742-6596/1233/1/012043

Hasbi, M., Lukito, A., & Sulaiman, R. (2019). Mathematical Connection Middle-School Students 8 th in Realistic Mathematics Education. *Journal of Physics: Conference Series*, *1417*(1), 012047. https://doi.org/10.1088/1742-6596/1417/1/012047

Hebert, M. A., & Powell, S. R. (2016). Examining fourth-grade mathematics writing: features of organization, mathematics vocabulary, and mathematical representations.

Reading and Writing, *29*(7), 1511–1537. https://doi.org/10.1007/s11145-016-9649-5

Hendradi, F. (2021). Penyelesaikan Soal Geometri Ruang Ditinjau dari Tingkat Kecerdasan Visual Spasial Siswa Kelas XII IPA SMA Negeri 2 Mejayan: Analisis Kemampuan Reprentasi Matematis Siswa. *JPT: Jurnal Pendidikan Tematik*, *2*(3), 339–344. https://siducat.org/index.php/jpt/article/view/362

Hermans, S., Neutens, T., Wyffels, F., & Van Petegem, P. (2024). Empowering Vocational Students: A Research-Based Framework for Computational Thinking Integration. *Education Sciences*, *14*(2), 206. https://doi.org/10.3390/educsci14020206

Hindal, H. S. (2014). Visual-spatial learning: A characteristic of gifted students. *European Scientific Journal*, *10*(13). https://core.ac.uk/download/pdf/236412891.pdf

Hoffmann, A., & Even, R. (2024). What do mathematicians wish to teach teachers about the discipline of mathematics? *Journal of Mathematics Teacher Education*, *27*(3), 479–497. https://doi.org/10.1007/s10857-023-09577-4

Hoogland, K., de Koning, J., Bakker, A., Pepin, B. E. U., & Gravemeijer, K. (2018). Changing representation in contextual mathematical problems from descriptive to depictive: The effect on students' performance. *Studies in Educational Evaluation*, *58*, 122–131. https://doi.org/10.1016/j.stueduc.2018.06.004

Huinker, D. (2018). Principles to Actions: Moving to a framework for teaching mathematics. *Teaching Children Mathematics*, *25*(3), 133–136. https://doi.org/10.5951/teacchilmath.25.3.0133

Indrawati, S. M., & Kuncoro, A. (2021). Improving Competitiveness Through Vocational and Higher Education: Indonesia's Vision For Human Capital Development In 2019–2024. *Bulletin of Indonesian Economic Studies*, *57*(1), 29–59. https://doi.org/10.1080/00074918.2021.1909692

Jablonka, E. (2020). Critical thinking in mathematics education. *Encyclopedia of Mathematics Education*, 159–163. https://doi.org/10.1007/978-3-030-15789-0_35

Jaedun, A., Nurtanto, M., Mutohhari, F., Saputro, I. N., & Kholifah, N. (2024). Perceptions of vocational school students and teachers on the development of interpersonal skills towards Industry 5.0. *Cogent Education*, *11*(1), 2375184. https://doi.org/10.1080/2331186X.2024.2375184

Jahangiri, J., Oxman, V., & Stupel, M. (2022). Testing the NCTM 2020 Standards Using Rigorous Mathematics and Multiple Solutions to a Single Geometric Problem. *Resonance*, *27*(6), 1061–1077. https://doi.org/10.1007/s12045-022-1397-z

Jitendra, A. K., Nelson, G., Pulles, S. M., Kiss, A. J., & Houseworth, J. (2016). Is Mathematical Representation of Problems an Evidence-Based Strategy for Students With Mathematics Difficulties? *Exceptional Children*, *83*(1), 8–25. https://doi.org/10.1177/0014402915625062

Kyttälä, M., & Björn, P. M. (2022). Mathematics Performance Profiles and Relation to Math Avoidance in Adolescence: The Role of Literacy Skills, General Cognitive Ability and Math Anxiety. *Scandinavian Journal of Educational Research*, *66*(7), 1221–1236. https://doi.org/10.1080/00313831.2021.1983645

Lee, J.-E., & Hwang, S. (2022). Elementary Students' Exploration of the Structure of a Word Problem Using Representations. *International Electronic Journal of Elementary Education*, *14*(3), 269–281. https://eric.ed.gov/?id=EJ1338812

Li, M., Chen, Y., Yang, J., Wang, Q., & Ye, X. (2025). The relationship of spatial visualization ability and number representation: evidence from multiple tasks. *BMC Psychology*, *13*(1), 33. https://doi.org/10.1186/s40359-024-02340-1

Lutfi, J. S., & Juandi, D. (2023). Mathematical representation ability: A systematic literature review. *Union: Jurnal Ilmiah Pendidikan Matematika*, *11*(1), 124-135. https://doi.org/10.30738/union.v11i1.14048

Nika, D. (2025). Social inequalities at the transition to higher education: the role of personality for graduates from vocational and general schools. *Empirical Research in Vocational Education and Training*, *17*(1), 7. https://doi.org/10.1186/s40461-025-00181-9

Niss, M., & Højgaard, T. (2019). Mathematical competencies revisited. *Educational Studies in Mathematics*, *102*(1), 9–28. https://doi.org/10.1007/s10649-019-09903-9

Putra, F. G., Lengkana, D., Sutiarso, S., Nurhanurawati, N., Saregar, A., Diani, R., Widyawati, S., Suparman, S., Imama, K., & Umam, R. (2023). Mathematical representation: A bibliometric mapping of the research literature (2013–2022). *Infinity Journal*, *13*(1), 1–26. https://doi.org/10.22460/infinity.v13i1.p1-26

Putra, B. Y. G., Rosita, N. T., & Hidayat, W. (2020). Profile of mathematical representation ability of junior high school students in Indonesia. In *Journal of Physics: Conference Series* (Vol. 1657, No. 1, p. 012003). IOP Publishing. https://doi.org/10.1088/1742-6596/1657/1/012003

Riastuti, N., Mardiyana, M., & Pramudya, I. (2017). Students' Errors in Geometry Viewed from Spatial Intelligence. *Journal of Physics: Conference Series*, *895*(1), 012029. https://doi.org/10.1088/1742-6596/895/1/012029

Sari, I. K., Nasriadi, A., Amalia, Y., & Setiawati, F. A. (2023). Mathematical Representation Ability of Junior High School Students: A Case Study of Students' Cognitive Ability through Realistic Mathematics Education. *Mosharafa: Jurnal Pendidikan Matematika*, *12*(3), 453-464. https://doi.org/10.31980/mosharafa.v12i3.2556

Smith, C., & Morgan, C. (2016). Curricular orientations to real-world contexts in mathematics. *The Curriculum Journal*, *27*(1), 24–45.

Sumandya, I. W., & Widana, I. W. (2022). Reconstruction of Vocational-Based Mathematics Teaching Materials using a Smartphone. *Journal of Education Technology*, *6*(1), 133–139. https://doi.org/10.23887/jet.v6i1.42833

Turan, E., & De Smedt, B. (2022). Mathematical language and mathematical abilities in preschool: A systematic literature review. *Educational Research Review*, *36*, 100457. https://doi.org/10.1016/j.edurev.2022.100457

Van Garderen, D., & Montague, M. (2003). Visual-Spatial Representation, Mathematical Problem Solving, and Students of Varying Abilities. *Learning Disabilities Research & Practice*, *18*(4), 246–254. https://doi.org/10.1111/1540-5826.00079

Weimer, J., Ruppert, J., Vieth, T., Weinmann-Menke, J., Buggenhagen, H., Künzel, J., Rink, M., Lorenz, L., Merkel, D., Ille, C., Yang, Y., Müller, L., Kloeckner, R., & Weimer, A. (2024). Effects of undergraduate ultrasound education on cross-sectional image understanding and visual-spatial ability - a prospective study. *BMC Medical Education*, *24*(1), 619. https://doi.org/10.1186/s12909-024-05608-7

Yoto, Marsono, Suyetno, A., Mawangi, P. A. N., Romadin, A., & Paryono. (2024). The role of industry to unlock the potential of the Merdeka curriculum for vocational school. *Cogent Education*, *11*(1), 2335820.

Zirkle, C. (2017). A Qualitative Analysis of High School Level Vocational Education in the United States – Three Decades of Positive Change. In *Vocational education and training in times of economic crisis: Lessons from around the world* (pp. 321–337). Springer. https://doi.org/10.1007/978-3-319-47856-2_17