Cakrawala Pendidikan
Jurnal Ilmiah Pendidikan
Vol. 43 No. 3, October 2024, pp.746-755
https://journal.uny.ac.id/index.php/cp/issue/view/2750
DOI: https://doi.org/10.21831/cp.v43i3.65013

Analysis of mathematical literacy through the lens of students' spatial geometry aptitude

Zainnur Wijayanto, Sukestiyarno*, Kristina Wijayanti, Emi Pujiastuti
Universitas Negeri Semarang, Indonesia
*Corresponding Author: sukestiyarno@mail.unnes.ac.id

ABSTRACT

Mathematical literacy assumes a significant role in helping students resolve everyday problems. The research is descriptive qualitative, which aims to assess students' literacy skills by categorizing them as high, moderate, or low based on various mathematical literacy indicators on the spatial facets of geometry. Research results were analyzed and sorted into categories denoting high, moderate, and low mathematical abilities, with one research subject chosen from each category from 32 students. It reveals that students with high mathematical test abilities were able to formulate and apply appropriate formulas, interpret, and effectively communicate results, as well as draw accurate conclusions. Students with moderate abilities were only able to formulate and interpret while requiring more ability to effectively communicate, provide suitable conclusions, or evaluate the problems. Lastly, the low ones needed help to solve the given problems and indicators.

Keywords: analysis, mathematical literacy, spatial geometry

Article history

Received:	*Revised:*	*Accepted:*	*Published:*
7 January 2024	*2 March 2024*	*27 May 2024*	*24 September 2024*

Citation (APA Style): Wijayanto, Z., Sukestiyarno, S., Wijayanti, K., & Pujiastuti, E. (2024). Analysis of mathematical literacy through the lens of students' spatial geometry aptitude. *Cakrawala Pendidikan: Jurnal Ilmiah Pendidikan, 43*(3), 746-755. DOI: https://doi.org/10.21831/cp.v43i3.65013

INTRODUCTION

Education is vital in facing various challenges (Islam et al., 2015) that require implementing knowledge in everyday life, including mathematical literacy skills (Umbara & Suryadi, 2019). Mathematical literacy is simply a person's ability to formulate, use, and interpret mathematics in various contexts (Colwell & Enderson, 2016). Since 2000, the Programme for International Student Assessment (PISA) of the Organisation for Economic Co-operation and Development (OECD) has regularly assessed students' reading comprehension and mathematics literacy every three years (Brindley, 2012). The PISA assessment of students' mathematical literacy skills reveals that students have yet to attain the highest level, commonly called level 6ts (Stacey, 2011). In the assessment of PISA, Indonesia ranked 71st, standing considerably behind neighbouring Southeast Asian nations such as Thailand, Singapore, and Malaysia, showing that its students remain below grade level (Figure 1).

A diversity of inquiries and content selections are among the factors that contribute to this sphere of issues. Students must have solid mathematical literacy skills to compete with other countries in globalized world (Firdaus & Herman, 2017). Since mathematics is closely connected to daily life, having mathematical literacy abilities is also essential. Furthermore, students' capacity to critically evaluate, rationally explain, and effectively express their ideas in mathematical contexts is crucial to mathematical literacy. This notion aligns with Niemi et al.'s (2018) statements that the focus of mathematical literacy is on how students construct and apply mathematics in a variety of situations to solve problems in daily life rather than simply using concepts, methods, and facts as mathematical instruments to express and explain the phenomena at hand.

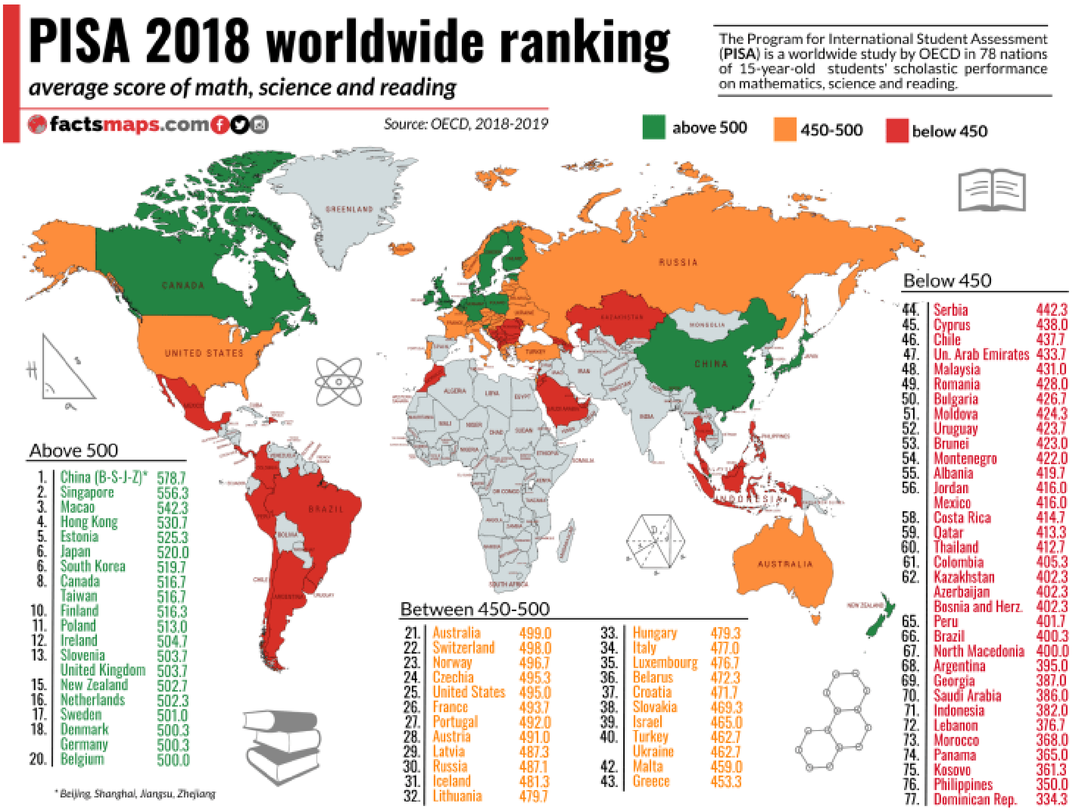


Figure 1. The assessment of PISA (2018)
Source: OECD, 2018-2019

Apart from the PISA assessment system, Indonesia's assessment system has yet to specifically develop students' mathematical literacy skills. Our assessment system is the National Exam, whereby the level of questions administered has a relatively low cognitive impact on the students (Dunlosky et al., 2013). Those questions cannot identify students' mathematical literacy skills in high-level cognitive aspects; thus, a different method is urgently required to examine students' mathematical literacy skills. Several recent studies on mathematical literacy address the relationship between process data and contextual variables among Scandinavian students working on the PISA 2012 mathematics questions (Costa & Chen, 2023). Another study explored the life experiences of gifted and high-achieving students with mathematics enrichment programs based on PISA (Almarashdi et al., 2023). The most current study investigated junior high school students' experiences with mathematical literacy (Bolstad, 2021).

Meanwhile, the study conducted by the researcher replicates the survey by Sikko (2023), which explores various things from multiple understandings of students' mathematical literacy. However, this study focuses more on analyzing mathematical literacy skills in terms of students' spatial geometry skills. Those studies indicate a research gap in terms of analysing mathematical literacy skills from the viewpoint of students' ability in spatial geometry.

After analyzing 177 articles on mathematical literacy using Program R and Scopus metadata, mathematical literacy has been extensively studied in various contexts. However, prior studies have not explicitly focused on the connection between mathematical literacy and spatial geometry. Existing studies have explored mathematical literacy concerning topics such as geometry, geometrical reasoning, and geometric manipulation (as depicted in Fig. 2). The study has also been conducted on mathematical literacy in the field of algebra and algebraic operations, indicated by the presence of green dots in the visual representation.

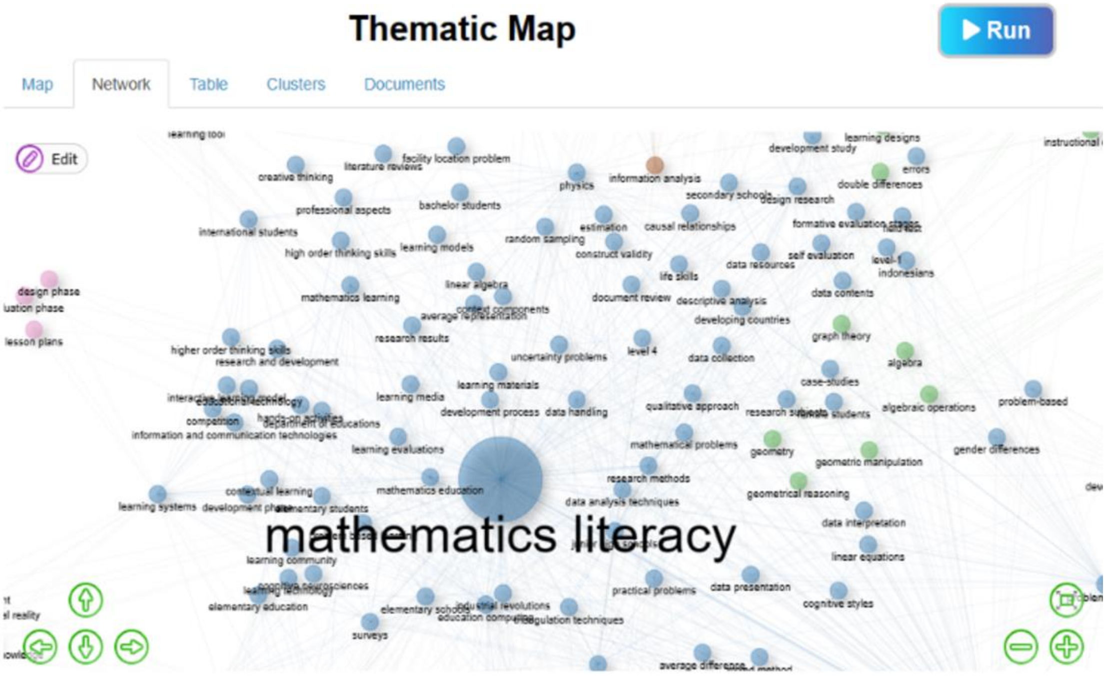


Figure 2. Thematic Map of Mathematics Literacy Research

This study aims to propose new indicators and examine their effectiveness in enhancing mathematical literacy. By analysing the results obtained from these new indicators, their appropriateness as methods for improving students' mathematical literacy skills can be established. Additionally, this study assesses students' literacy skills by categorizing them as high, medium, or low based on each mathematical literacy indicator. The findings of this study will provide valuable insights for selecting appropriate strategies to enhance students' mathematical literacy skills, thereby making a significant contribution to the field.

METHOD

The research design utilized in this study is a descriptive qualitative method, which aims to provide a detailed description and analysis of students' mathematical literacy skills. This research design allows for a comprehensive exploration of the subject matter by examining the phenomena in its natural setting and gathering rich, non-numerical data. Through observations, interviews, and analysis of test results, the study seeks to determine students' mathematical literacy skills level, classifying them into high, medium, or low categories based on the specific mathematical literacy indicators: formulate, apply, interpret, communicate, and evaluate. Each indicator of mathematical literacy ability is presented in Table 1.

Table 1. Indicators of mathematical literacy ability

Indicators	Descriptions
Formulate	Formulate the problem in a mathematical form or model
Apply	Using mathematical concepts, facts, and procedures to solve problems
Interpret	Provide reasoning and arguments based on mathematical information or mathematical problem solutions.
Communications	Communicate results or solutions
Evaluate	Evaluate results or solutions and draw conclusions

This research design offers a nuanced understanding of students' abilities and contributes to developing strategies for enhancing mathematical literacy skills in the targeted population. The research design in this study employed a purposive sampling technique to select a specific group of participants. The students were chosen as the sample based on predetermined criteria into high, medium, and low categories based on the math test results. The criteria for grouping students' basic mathematical abilities are shown in Table 2.

Table 2. The criteria for grouping students' basic mathematical abilities

Score	Mathematical Literacy Criteria
test scores $\geq mean$ + SD	High
$mean$ – SD $\leq$ test score < $mean$ + SD	Medium
test score < $mean$ – SD	Low

Note:
SD: Standard deviation

The purposive sampling approach allowed for selecting participants deemed most relevant to the research objectives. Data collection was conducted through an administered mathematics test. The test consisted of a series of mathematics problems to assess their mathematical literacy skills. The students' responses and performance on the test were recorded and used as primary data for the study. Additionally, the researchers employed qualitative data collection methods, such as interviews or observations, to gather supplementary information about the students' mathematical literacy. These methods allowed a deeper understanding of the students' problem-solving approaches, thought processes, and reasoning abilities.

The combination of quantitative data from the mathematics test and qualitative data from interviews or observations provided a comprehensive dataset for analysis. After defining the categorization criteria, students falling within the high, medium, and low groups were identified. Six students were carefully chosen using a purposive selection strategy, with the research aim of conducting an in-depth analysis of students' mathematical literacy abilities in mind.

Moreover, a meticulous qualitative analysis was performed on the test outcomes, focus on the discernible indicators of mathematical literacy, such as formulating, applying, interpreting, communicating, and evaluating. To reinforce the interpretation of the gathered data, the researcher judiciously employed data triangulation techniques, meticulously amalgamating the results obtained from interviews with the substantial corpus of data derived from the mathematics tests.

FINDINGS AND DISCUSSION

Findings

The subjects were first grouped based on their mathematical ability before being analyzed the students' mathematical literacy ability in terms of their spatial ability.

Group of Students' Basic Mathematical Abilities

The student grouping data obtained based on the student mathematical ability category is shown in Figure 3.

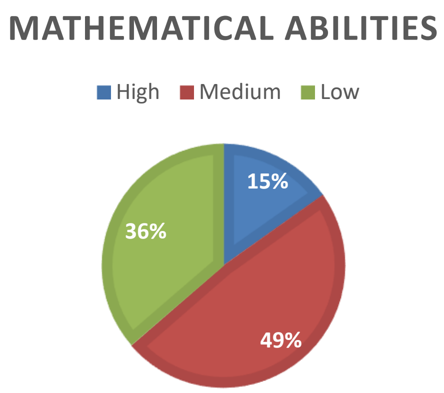
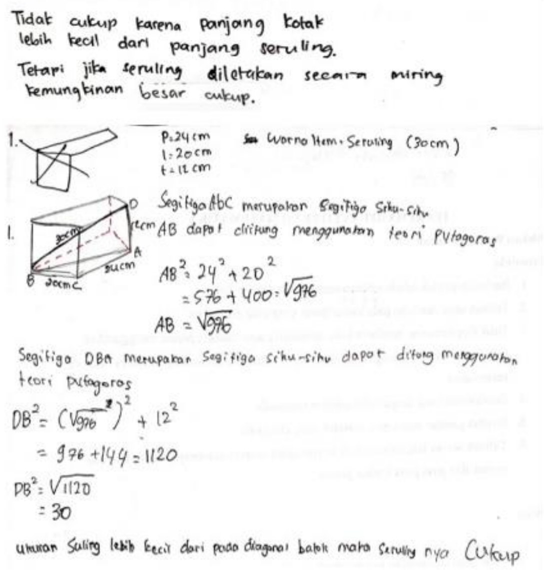


Figure 3. Grouping of Students' Basic Mathematical Abilities

The findings suggest that many students fall within the moderate mathematical ability category. In contrast, a comparatively smaller proportion of students are classified within the high mathematical ability category.

Results of Mathematical Test

The results of the mathematical test of students with high, medium, and low essential mathematical abilities are presented in Figure 4, Figure 5, and Figure 6.

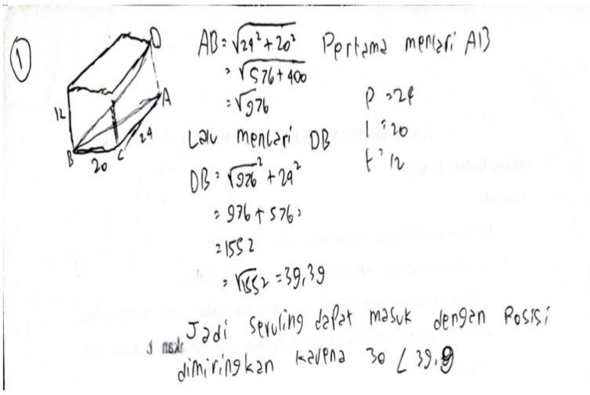


Not enough, because the length of the box is smaller than the length of the flute. But if the flute is placed on its side maybe will fit.
$p = 24$ cm
$l = 20$ cm
$t = 12$ cm
Triangle ABC defined as Right Triangle Shape
AB can be calculated using pythagoras
$AB^2 = 24^2 + 20^2$
$= 576 + 400 = \sqrt{976}$
$AB = \sqrt{976}$
Triangle DBA defined as Right Triangle Shape that can be calculated using pythagoras
$DB^2 = (\sqrt{976})^2 + 12^2$
$= 976 + 144 = 1120$
$DB^2 = \sqrt{1120} = 30$

The size of the flute is smaller than the beam diagonals, so the flute fit in the box.

Figure 4. Answers of Students with High Basic Mathematical Ability

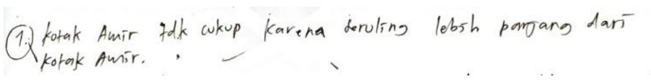
High-level students demonstrate advanced mathematical abilities across the literacy ability indicators (Fig. 4).



$AB = \sqrt{24^2 + 20^2}$ First, calculate AB
$= \sqrt{576 + 400}$ $p = 28$
$= \sqrt{976}$ $l = 20$
Then, calculate DB $t = 12$
$DB = (\sqrt{976})^2 + 24^2$
$= 976 + 576$
$= 1552$
$= \sqrt{1552} = 39{,}39$
So the flute can be inserted into the box on tilted position because $30 < 39{,}39$

Figure 5. Answers of Students with Medium Basic Mathematical Ability

Medium-level students demonstrate moderate mathematical abilities across literacy indicators (Fig. 5).



Amir's box is not enough because the flute is longer than Amir's box

Figure 6. Answers of Students with Low Basic Mathematical Ability

Low-level students demonstrate limited mathematical abilities across the literacy ability indicators of formulating, applying, interpreting, communicating, and evaluating (Fig. 6).

Discussion

The analysis of mathematical ability of students based on high, medium, and low categories based on mathematical literacy indicators: formulating, applying, interpreting, communicating, and evaluating.

High Basic Mathematical Abilities

High-level students excel at accurately and precisely translating real-world spatial situations into mathematical representations (Sanwidi, 2018). They can construct sophisticated geometric models, diagrams, or equations that effectively capture the essence of the given problems. Their formulations demonstrate a high level of precision, coherence, and completeness.

Students exhibit a deep understanding of geometric principles and formulas. They can effortlessly identify relevant geometric concepts applicable to a given situation and apply them with precision and accuracy. They employ advanced strategies and techniques to solve complex problems, demonstrating high proficiency in formulas and procedures. High-level students showcase exceptional skills in interpreting spatial geometry information. They possess a profound understanding of geometric figures, diagrams, or visual representations, allowing them to analyze and discern intricate geometric properties, angles, or relationships. Their interpretations are insightful and comprehensive and consider multiple relevant aspects. They exhibit a high level of proficiency in understanding spatial relationships and geometric concepts.

They also articulate their mathematical ideas and reasoning with clarity and precision. They fully employ mathematical language, vocabulary, and notation to describe complex geometric concepts and processes. Their coherent, logical, and comprehensible explanations facilitate effective communication and understanding. Students demonstrate exceptional abilities in critically assessing geometric arguments and solutions. They exhibit strong analytical skills, identifying subtle errors or weaknesses in geometric reasoning or proofs. They are keen to judge the validity, reliability, and appropriateness of geometric solutions or strategies. Their evaluations and justifications are thorough and rigorous and demonstrate high proficiency.

Overall, high-level students showcase advanced mathematical abilities in the context of spatial geometry (Ramírez-Uclés & Ruiz-Hidalgo, 2022). Their exceptional skills in formulating accurate geometric representations, applying complex geometric concepts, interpreting intricate geometric information, communicating mathematical ideas effectively, and evaluating geometric arguments and solutions set them apart. Their exemplary proficiency in these literacy ability indicators highlights their mastery of spatial geometry and their ability to handle complex mathematical challenges.

Medium Basic Mathematical Abilities

Medium-level students can generate geometric representations and models that partially capture the essence of the given problems (Puig et al., 2022). While they may successfully translate real-world spatial situations into mathematical expressions or diagrams, their formulations may need more precision and completeness. They exhibit a moderate level of proficiency in constructing accurate geometric representations.

Students display a satisfactory understanding of geometric principles and formulas. They can identify relevant geometric concepts applicable to a given situation and apply them appropriately. However, they may occasionally encounter challenges in selecting the most efficient or effective geometric strategies or techniques to solve complex problems. Their application of formulas and procedures demonstrates a moderate level of proficiency. They exhibit a satisfactory ability to interpret spatial geometry information. They can analyze geometric figures, diagrams, or visual representations to a certain extent. They can identify basic geometric properties, angles, or relationships. However, their interpretations may need more depth or consider only some relevant aspects. Their understanding of spatial relationships and geometric concepts is moderately developed.

Medium-level students can effectively express mathematical ideas and reasoning (Suryaningrum et al., 2020). They demonstrate a reasonable command of mathematical language, vocabulary, and notation to describe geometric concepts and processes. Their explanations are generally coherent and understandable, allowing others to grasp their reasoning. Students possess a moderate ability to assess geometric arguments and solutions critically. They can identify some errors or weaknesses in geometric reasoning or proofs. They show an emerging ability to judge the validity, reliability, or appropriateness of geometric solutions or strategies. Their evaluations and justifications demonstrate a moderate level of proficiency.

Overall, medium-level students exhibit a satisfactory level of mathematical abilities in the context of spatial geometry. They demonstrate competence in formulating geometric representations, applying relevant geometric concepts, interpreting geometric information, communicating mathematical ideas effectively, and evaluating geometric arguments and solutions. While they still have room for further improvement, their moderate proficiency indicates a solid foundation for continued growth and development in spatial geometry skills.

Low Basic Mathematical Abilities

Low-level students need help translating real-world spatial situations into mathematical representations effectively. They find it challenging to construct accurate and coherent geometric models, diagrams, or equations corresponding to the given problems (Scheid et al., 2019). Their formulations may need more precision and clarity or may even be absent. In terms of applying mathematical concepts in spatial geometry, low-level students encounter difficulties utilizing geometric principles and formulas to solve problems. They need help to identify the relevant geometric concepts applicable to a given situation and apply them correctly. Their application of formulas and procedures may need to be more accurate or complete, leading to incorrect solutions or incomplete responses.

Low-level students also need help with interpreting spatial geometry information. They find it challenging to analyse geometric figures, diagrams, or visual representations. They may struggle to identify geometric properties, angles, or relationships, leading to incorrect interpretations or misjudgments. Their understanding of spatial relationships and geometric concepts needs to be improved, hindering their ability to make meaningful interpretations. Regarding communication in the context of spatial geometry, low-level students struggle to express their mathematical ideas clearly and effectively. They struggle to use appropriate mathematical language, vocabulary, and notation to describe geometric concepts and processes. Their explanations may need coherence, clarity, and precision, making it challenging for others to understand their reasoning. The students have limited skills in critically assessing geometric arguments and solutions. They struggle to identify errors or weaknesses in geometric reasoning or proofs. Their ability to judge the validity, reliability, or appropriateness of geometric solutions or strategies is limited, resulting in difficulties providing meaningful evaluations or justifications.

Overall, low-level students face significant challenges in spatial geometry, exhibiting limitations in formulating accurate geometric representations, applying appropriate geometric concepts, interpreting geometric information, communicating mathematical ideas effectively, and evaluating geometric arguments and solutions. These limitations highlight the importance of targeted interventions and instructional support to enhance their mathematical abilities in spatial geometry.

Building on existing findings, future studies in this field can focus on several promising avenues. Longitudinal studies will track the development of students' spatial geometry aptitude and mathematical literacy over an extended period. By following a cohort of students from early education to later stages, researchers can understand how spatial geometry aptitude influences the progression of mathematical literacy and its long-term impact. Additionally, intervention studies can be designed to improve students' spatial geometry aptitude and assess their impact on mathematical literacy through targeted instructional programs or activities. By comparing intervention and control groups, researchers can establish a causal relationship between spatial geometry aptitude improvements and enhancements in mathematical literacy. Exploring the relationship between spatial geometry aptitude and mathematical literacy across different cultures and educational systems through cross-cultural studies can provide insights into the factors influencing this relationship. Comparative studies can highlight similarities and differences, leading to a comprehensive understanding. Moreover, the potential of technology-based approaches, such as computer-based simulations or virtual reality, can be explored to enhance spatial geometry aptitude and mathematical literacy by providing engaging experiences that promote spatial reasoning skills. Lastly, investigating the role of teacher professional development in fostering students' spatial geometry aptitude and mathematical literacy can inform effective pedagogical practices and contribute to integrating spatial geometry aptitude in mathematics instruction.

CONCLUSION

The research findings provide valuable insights into the level of students' mathematical literacy skills and highlight the need for targeted strategies to enhance these abilities. The analysis of 177 articles on mathematical literacy indicates that while previous studies have extensively explored mathematical literacy, there is a significant gap in the literature regarding mathematical literacy associated with spatial geometry. The study introduces new indicators to measure mathematical literacy and demonstrates their potential to provide meaningful findings. The positive results obtained from these new indicators suggest that they can be further explored and utilized as effective methods to improve students' mathematical literacy skills. This opens up opportunities for future studies to develop and refine these indicators, contributing to the advancement of mathematical literacy education. Based on each mathematical literacy indicator, the research categorizes students' literacy skills into high, medium, and low levels. This categorization assists in identifying areas of strength and areas that require improvement among students. The findings are a foundation for selecting appropriate strategies and interventions to enhance students' mathematical literacy abilities. In conclusion, this research contributes significantly to the field of mathematical literacy by identifying the gaps in previous studies and introducing new indicators for assessment. The findings emphasize the importance of developing students' mathematical literacy skills, particularly in spatial geometry. The research outcomes provide a basis for future studies to explore and implement practical approaches to improve students' mathematical literacy, ultimately empowering them to tackle real-life problems and succeed in various academic and professional domains.

REFERENCES

Almarashdi, H. S., Mohamed, A. H., & Jarrah, A. M. (2023). Towards equity: Exploring gifted and high achieving students' lived experiences with a mathematical enrichment program based on PISA. *Sustainability*, *15*(5), 4658. https://doi.org/10.3390/su15054658

Benton, L., Saunders, P., Kalas, I., Hoyles, C., & Noss, R. (2018). Designing for learning mathematics through programming: A case study of pupils engaging with place value. *International Journal of Child-Computer Interaction*, *16*, 68–76. https://doi.org/10.1016/j.ijcci.2017.12.004

Bolstad, O. H. (2021). Lower secondary students' encounters with mathematical literacy. *Mathematics Education Research Journal*, 1–17. https://doi.org/10.1007/s13394-021-00386-7

Brindley, S. (2012). Teenagers and reading: literary heritages, cultural contexts and contemporary. *Sociology of Education*, *20*(2), 239–263

Buzsáki, G., & Tingley, D. (2018). Space and time: The hippocampus as a sequence generator. *Trends in Cognitive Sciences*, *22*(10), 853–869. https://doi.org/10.1016/j.tics.2018.07.006.

Colwell, J., & Enderson, M. C. (2016). "When I hear literacy": Using pre-service teachers' perceptions of mathematical literacy to inform program changes in teacher education. *Teaching and Teacher Education*, *53*, 63–74. https://doi.org/10.1016/j.tate.2015.11.001

Costa, D. R., & Chen, C. W. (2023). Exploring the relationship between process data and contextual variables among Scandinavian students on PISA 2012 mathematics tasks. *Large-Scale Assessments in Education*, *11*(1), 1–28. https://doi.org/10.1186/s40536-023-00155

Davies, A., Veličković, P., Buesing, L., Blackwell, S., Zheng, D., Tomašev, N., Tanburn, R., Battaglia, P., Blundell, C., & Juhász, A. (2021). Advancing mathematics by guiding human intuition with AI. *Nature*, *600*(7887), 70–74. https://doi.org/10.1038/s41586-021-04086-x

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest*, *14*(1), 4–58. https://doi.org/10.1177/1529100612453266

Firdaus, F. M., & Herman, T. (2017). Improving primary students' mathematical literacy through problem-based learning and direct instruction. *Educational Research and Reviews*, *12*(4), 212–219. https://doi.org/10.5897/ERR2016.3072

Gal, I., Grotlüschen, A., Tout, D., & Kaiser, G. (2020). Numeracy, adult education, and vulnerable adults: A critical view of a neglected field. *Zdm*, *52*, 377–394. https://doi.org/10.1007/s11858-020-01155-9

Hawes, Z., & Ansari, D. (2020). What explains the relationship between spatial and mathematical skills? A review of evidence from brain and behavior. *Psychonomic Bulletin & Review*, *27*, 465–482. https://doi.org/10.3758/s13423-019-01694-7

Hu, X., Gong, Y., Lai, C., & Leung, F. K. S. (2018). The relationship between ICT and student literacy in mathematics, reading, and science across 44 countries: A multilevel analysis. *Computers & Education*, *125*, 1–13. https://doi.org/10.1016/j.compedu.2018.05.021

Islam, N., Beer, M., & Slack, F. (2015). E-learning challenges faced by academics in higher education. *Journal of Education and Training Studies*, *3*(5), 102–112. http://dx.doi.org/10.11114/jets.v3i5.947

Jelatu, S., & Ardana, I. (2018). Effect of geogebra-aided REACT strategy on understanding of geometry concepts. *International Journal of Instruction*, *11*(4), 325–336

Kozakli Ulger, T., Bozkurt, I., & Altun, M. (2022). Analyzing in-service teachers' process of mathematical literacy problem posing. *International Electronic Journal of Mathematics Education*, *17*(3), em0687. https://doi.org/10.29333/iejme/11985

Lewinsky, K. M. (2017). Examining the relationship between secondary mathematics teachers' self-efficacy, attitudes, and use of technology to support communication and mathematics literacy. *International Journal of Research in Education and Science*, *3*(1), 56–66. https://doi.org/10.21890/ijres.267371

Miller, H. E., Andrews, C. A., & Simmering, V. R. (2020). Speech and gesture production provides unique insights into young children's spatial reasoning. *Child Development*, *91*(6), 1934–1952. https://doi.org/10.1111/cdev.13396

Niemi, H., Shuanghong, N. İ. U., Vivitsou, M., & Baoping, L. İ. (2018). Digital storytelling for twenty-first-century competencies with math literacy and student engagement in China and Finland. *Contemporary Educational Technology*, *9*(4), 331–353. https://doi.org/10.30935/cet.470999

Özreçberoğlu, N., & Çağanağa, Ç. K. (2018). Making it count: Strategies for improving problem-solving skills in mathematics for students and teachers' classroom management. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(4), 1253–1261. https://doi.org/10.29333/ejmste/82536

Peterson, R. L., McGrath, L. M., Willcutt, E. G., Keenan, J. M., Olson, R. K., & Pennington, B. F. (2021). How specific are learning disabilities? *Journal of Learning Disabilities*, *54*(6), 466–483. https://doi.org/10.1177/0022219420982981

Puig, A., Rodríguez, I., Baldeón, J., & Múria, S. (2022). Children build and have fun while they learn geometry. *Computer Applications in Engineering Education*, *30*(3), 741–758. https://doi.org/10.1002/cae.22484

Ramírez-Uclés, R., & Ruiz-Hidalgo, J. F. (2022). Reasoning, representing, and generalizing in geometric proof problems among 8th grade talented students. *Mathematics*, *10*(5), 789. https://doi.org/10.3390/math10050789

Salam, M., Ibrahim, N., & Sukardjo, M. (2019). Effects of instructional models and spatial intelligence on the mathematics learning outcomes after controlling for students' initial competency. *International Journal of Instruction*, *12*(3), 699–716. https://doi.org/10.29333/iji.2019.12342a

Sanwidi, A. (2018). Students'representation in solving word problem. *Infinity Journal*, *7*(2), 147–154. https://doi.org/10.22460/infinity.v7i2.p147-154

Scheid, J., Müller, A., Hettmannsperger, R., & Schnotz, W. (2019). Improving learners' representational coherence ability with experiment-related representational activity tasks. *Physical Review Physics Education Research*, *15*(1), 10142. https://doi.org/10.1103/PhysRevPhysEducRes.15.010142

She, H. C., Stacey, K., & Schmidt, W. H. (2018). Science and mathematics literacy: PISA for better school education. *International Journal of Science and Mathematics Education*, *16*, 1–5. https://doi.org/10.1007/s10763-018-9911-1

Sikko, S. A. (2023). What can we learn from the different understandings of mathematical literacy? *Numeracy*, *16*(1), 1. https://doi.org/10.5038/1936-4660.16.1.1410

Simamora, R. E., & Saragih, S. (2019). Improving students' mathematical problem solving ability and self-efficacy through guided discovery learning in local culture context. *International Electronic Journal of Mathematics Education*, *14*(1), 61–72. https://doi.org/10.12973/iejme/3966

Stacey, K. (2011). The PISA view of mathematical literacy in Indonesia. *Journal on Mathematics Education*, *2*(2), 95–126. https://doi.org/10.22342/jme.2.2.746.95-126

Sumirattana, S., Makanong, A., & Thipkong, S. (2017). Using realistic mathematics education and the DAPIC problem-solving process to enhance secondary school students' mathematical literacy. *Kasetsart Journal of Social Sciences*, *38*(3), 307–315. https://doi.org/10.1016/j.kjss.2016.06.001

Suryaningrum, C. W., Susanto, H., Ningtyas, Y. D. W. K., & Irfan, M. (2020). Semiotic reasoning emerges in constructing properties of a rectangle: A study of adversity quotient. *Journal on Mathematics Education*, *11*(1), 95–110. http://doi.org/10.22342/jme.11.1.9766.95-110

Tamm, L., McNally, K. A., Altaye, M., & Parikh, N. A. (2023). Mathematics abilities associated with adaptive functioning in preschool children born preterm. *Child Neuropsychology*, 1–14. https://doi.org/10.1080/09297049.2023.2191942

Tout, D. (2020). Evolution of adult numeracy from quantitative literacy to numeracy: Lessons learned from international assessments. *International Review of Education*, *66*, 183–209. https://doi.org/10.1007/s11159-020-09831-4

Umbara, U., & Suryadi, D. (2019). Re-interpretation of mathematical literacy based on the teacher's perspective. *International Journal of Instruction*, *12*(4), 789–806. https://doi.org/10.29333/iji.2019.12450a