Literature Review: The Relationship Between Spatial Literacy Ability and Students' Mathematical Productive Dispositions in Mathematics Learning

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ABSTRACT

Meaningful mathematics learning requires a balance between cognitive and affective aspects, where spatial literacy skills and mathematical productive dispositions play an important role in shaping conceptual understanding and positive attitudes towards mathematics. This study aims to examine the relationship between students' spatial literacy skills and mathematical productive dispositions in the context of mathematics learning. The method used is a literature study with a qualitative descriptive approach through an analysis of 20 national and international articles published in the period 2019-2025. The results of the study indicate that spatial literacy skills contribute to improving mathematical visualization, representation, and reasoning abilities, while productive dispositions play a role in fostering students' perseverance, self-confidence, and learning motivation. These two aspects have a mutually reinforcing relationship and together determine the success of mathematics learning, so that understanding their relationship can be a foundation for developing a more comprehensive learning approach oriented towards strengthening students' thinking skills and learning character.

Keywords: *Mathematical productive disposition, Mathematics learning, Spatial ability, Spatial literacy*.

1) INTRODUCTION

Mathematics is a fundamental discipline that plays a crucial role in developing students' logical, analytical, and systematic thinking skills. According to Rusmana (2019), mathematics is not only concerned with numbers and calculations, but also with structures and relationships that reflect real-life patterns. This aligns with the NCTM (2019)'s assertion that mathematics provides a means for students to rationally interpret the world through patterns, representations, and models. Therefore, mastery of mathematics is not merely an academic goal but a crucial necessity in facing the challenges of the 21st century.

In an educational context, mathematics learning should not be limited to delivering material, but rather focus on fostering conceptual understanding and a positive attitude toward learning. Arafah et al. (2023) stated that mathematics learning is effective when teachers are able to create learning

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experiences that foster student exploration and reflection. Meanwhile, Lo et al. (2024) found that contextual and reflective learning can strengthen students' construction of meaning. Thus, the success of mathematics learning can be seen from the balance between cognitive and affective aspects that support active and meaningful student engagement.

One cognitive aspect that plays a significant role in mathematical understanding is spatial literacy. Mas'udah et al. (2021) define spatial literacy as the ability to mentally understand, reason, and manipulate relationships between objects in space. Susilowati et al. (2024) emphasize that this ability significantly influences mathematical achievement, particularly in problem-solving involving visualization or geometric representation. In fact, research by Sartika et al. (2025) shows that increased spatial ability correlates with speed and accuracy in solving mathematical problems. Therefore, spatial literacy is an important skill that must be developed through mathematics learning oriented toward visual representation.

Selain aspek kognitif, keberhasilan pembelajaran matematika juga ditentukan oleh faktor afektif seperti disposisi produktif matematis, yaitu kecenderungan untuk memiliki keyakinan, ketekunan, dan minat positif terhadap matematika (Syahputra, 2024). Nurinayah et al. (2022) menegaskan bahwa disposisi produktif berperan dalam menumbuhkan keuletan siswa menghadapi kesulitan belajar. Siswa dengan disposisi produktif tinggi akan memandang kesalahan sebagai bagian dari proses pembelajaran dan berusaha memperbaikinya. Dengan demikian, disposisi produktif tidak hanya memperkuat motivasi intrinsik, tetapi juga meningkatkan efektivitas penerapan kemampuan kognitif seperti berpikir spasial.

Several previous studies have highlighted the relationship between spatial ability and students' mathematical performance. For example, research by Atit et al. (2021) found that spatial skills can predict success in complex mathematical tasks. Khofifah et al. (2022) also revealed that students with high spatial ability are better able to understand geometric concepts and relationships between shapes. Furthermore, research by Anggraeni et al. (2019) showed that integrating spatial exercises into learning can significantly improve students' mathematical thinking skills. These findings reinforce the assumption that spatial literacy plays a crucial role in supporting mathematical thinking skills.

Meanwhile, several other studies highlight the role of productive dispositions in determining the quality of mathematics learning outcomes. Geofani & Syahputra (2024) found that students with positive productive dispositions demonstrated greater persistence and self-confidence in learning

mathematics. These findings are reinforced by research by Riyadi et al. (2024), which states that positive dispositions toward mathematics contribute to increased student engagement in problem-based learning. However, most of these studies still examine cognitive and affective aspects separately without examining the direct relationship between the two within the context of comprehensive mathematics learning.

Although various studies have addressed both spatial literacy and productive mathematical dispositions, most have examined them separately without examining their interconnectedness. Literature reviews indicate that spatial literacy plays a role in understanding visual representations and relationships, while productive dispositions contribute to persistence and confidence in solving mathematical problems. While both complement each other in the mathematical thinking process, the integrative relationship between these cognitive and affective aspects has not been explored in depth. Therefore, a study that examines the integration of these two aspects is necessary to gain a more comprehensive understanding of the quality of mathematics learning.

By considering the relationship between spatial literacy skills and mathematical productive dispositions, this literature review attempts to provide a more comprehensive understanding of the relationship between the two in the context of mathematics learning. Based on this description, the purpose of this study is to analyze the relationship between spatial literacy skills and students' mathematical productive dispositions simultaneously in mathematics learning through a literature review. The results of this study are expected to provide theoretical and practical contributions in developing a more comprehensive learning approach, which emphasizes not only cognitive achievement but also the formation of positive attitudes towards mathematics.

2) METHODS

This study used a literature review approach to analyze the relationship between spatial literacy skills and students' mathematical productive dispositions in mathematics learning. This approach allows researchers to examine and synthesize various relevant research findings without conducting field data collection (Snyder, 2019). The research method used was descriptive qualitative, as it focused on describing the results of previous studies to identify patterns of relationships between the two variables in the context of mathematics learning (Herlina et al., 2025).

The data sources were national and international journal articles published between 2019 to 2025, obtained through database searches such as Google Scholar, ScienceDirect, and Taylor & France using the keywords spatial ability, spatial literacy, productive disposition, and mathematics learning. Data analysis was conducted using content analysis in three stages: reduction, presentation, and conclusion drawing (Dhini & Rifani, 2021). To clarify the study results, the findings from each article are presented in a table containing the title, author, year, and research focus to systematically illustrate the relationship between the two variables.

3) RESULTS AND DISCUSSION

Based on the literature review, research on spatial literacy skills and mathematical productive dispositions shows considerable development in the context of mathematics learning. A search of articles published between 2019-2025 yielded 20 relevant scientific articles that met the study criteria. These articles included research on the development of learning media, correlational studies, and theoretical studies highlighting various efforts to improve mathematics learning outcomes through these two aspects. The following table presents the results of the review of the articles analyzed in this study.

Table 1: *Results of Literature Review*

Number	Article Title	Author (year)	Key Findings
1	*Spatial Literacy in Geometry Learning: A Systematic Literature Review*	Octaria et al. (2024)	Spatial literacy plays a crucial role in developing students' visual representation skills and understanding of geometry. Learning that emphasizes visual exploration, spatial manipulation, and spatial modeling has been shown to significantly improve geometric thinking skills.
2	*E-Book Development to Improve Spatial Literacy*	R. N. Putri & Nurafni (2025)	The use of interactive, multimedia-based e-books encourages active student

	in Elementary Geometry Learning		participation in understanding spatial concepts. Trial results indicate that this medium effectively improves students' representational skills, spatial imagination, and interest in mathematics learning.
3	*An Augmented Reality Learning Toolkit for Fostering Spatial Ability in Mathematics Lesson: Design and Development*	Ozcakir & Cakiroglu (2021)	AR technology enriches the learning experience by allowing students to directly visualize 3D objects. This contributes to improved spatial reasoning and cognitive engagement in mathematics learning.
4	*Investigating current patterns in spatial learning within the context of mathematics education in Asia: A systematic review*	Putri et al. (2025)	Spatial ability-based approaches have been widely integrated into mathematics curricula in various Asian countries. Learning based on spatial visualization and spatial representation has been shown to improve students' conceptual understanding and academic outcomes.
5	*Examining the role of spatial skills and mathematics motivation on middle school mathematics achievement*	Atit et al. (2020)	There is a strong positive relationship between spatial ability and motivation and mathematics achievement. Students with high levels of spatial ability tend to have greater

			confidence and persistence in solving mathematical problems.
6	*Spatial Reasoning and Its Contribution to Mathematical Performance Across Different Content Domains: Evidence from Chinese Students*	Xu et al. (2025)	Spatial reasoning makes a substantial contribution to solving problems in geometry, algebra, and measurement. The ability to manipulate spatial objects helps students transfer abstract concepts into more concrete visual forms.
7	*Navigating Spatial Ability for Mathematics Education: a Review and Roadmap*	Schenck & Nathan (2024)	This article summarizes various classifications of spatial ability and their measurement instruments, while also offering a roadmap for research development in this area. The authors emphasize the importance of developing authentic assessments to holistically evaluate students' spatial abilities.
8	*Spatial reasoning in context: bridging cognitive and educational perspectives of spatial-mathematics relations*	Harris (2023)	The integration of cognitive theory and educational perspectives provides a deeper understanding of how students develop spatial skills. Spatial understanding serves as a bridge between concrete experiences and abstract thinking in mathematics.

9	*Enhancing mathematical education with spatial visualization tools*	Herrera et al. (2024)	The use of visual aids such as 3D software and interactive visualization applications has been shown to strengthen spatial thinking skills and understanding of geometric concepts. This technology also helps increase student motivation and engagement during learning.
10	*Analisis Kemampuan Literasi Spasial Siswa pada Materi Transformasi Geometri*	Kustiawati et al. (2023)	Most students still have low levels of spatial literacy, particularly in reasoning and representation. This situation highlights the need for a visual-based and exploratory learning approach in geometry.
11	*The relationships of preservice teachers' dispositions and noticing of technology-integrated mathematics teaching activities*	Hsieh et al. (2025)	Prospective teachers' positive dispositions strongly influence their ability to recognize pedagogical opportunities and use technology reflectively. Teachers with productive dispositions are more sensitive to innovative learning strategies that support student engagement.
12	*Improving Students Productive Disposition through Realistic Mathematics Education with Outdoor Approach*	Haji et al. (2019)	The integration of contextual activities outside the classroom strengthens students' tenacity, curiosity, and self-confidence in learning mathematics. The RME

			approach, based on real-life experiences, encourages students to understand concepts more meaningfully.
13	*Analyzing The Productive Disposition And Its Correlation With Mathematics Achievement Of Islamic Junior High School Students*	Husniah et al. (2021)	A positive correlation was found between productive disposition and mathematics achievement. Students with a high disposition demonstrated greater motivation, persistence, and self-confidence when faced with challenging problems.
14	*Mathematics productive disposition as a correlate of senior secondary school students' achievement in mathematics in Nigeria*	Awofala et al. (2020)	A productive disposition is a crucial factor influencing mathematics learning outcomes. Students with a positive disposition are optimistic and persistent in solving complex mathematical problems.
15	*Cultivating a Productive-Disposition Toward Mathematics by Engaging in Service-Learning*	Wilkerson (2021)	Service-based learning activities encourage students to develop empathy, social responsibility, and confidence in their mathematical abilities. This contextual learning helps connect social values with mathematical practice.
16	*Improving learners' productive disposition through realistic*	Chua (2022)	This reflective study demonstrates that teachers' paradigm shifts in implementing

	mathematics education, a teacher's critical reflection of personal pedagogy		RME have a direct impact on student dispositions. More reflective teachers are able to build supportive learning environments that foster student self-confidence and perseverance.
17	*Enhancing Students' Strategic Competence with GeoGebra and Productive Disposition: Elevating Mathematics Learning in the Digital Age*	Rahman et al. (2025)	GeoGebra integration not only strengthens mathematical representation skills but also fosters positive attitudes toward learning. Students become more independent, confident, and have a more stable productive disposition in the digital learning context.
18	*Determinants of High School Students' Mathematics Achievement: The Role of Motivation, Self-Efficacy, and Productive Disposition*	Rahman (2025)	These three factors interact with each other and contribute significantly to academic achievement. A productive disposition acts as a strengthening factor in the relationship between motivation and self-efficacy, promoting learning success.
19	*Pengaruh Faktor Eksternal Terhadap Disposisi Produktif pada Kecakapan Matematis*	Hidayat et al. (2024)	Family support, school learning styles, and classroom climate have a significant influence on the development of productive dispositions. Positive external factors encourage students to be

			persistent, optimistic, and responsible in learning mathematics.
20	*Disposisi Produktif dalam Pembelajaran Matematika pada Siswa SMP Kelas IX*	Syahputra (2024)	Most students have a moderate level of productive disposition, with weaknesses in self-confidence and persistence in the face of difficulties. This research emphasizes the importance of teachers' role in fostering self-confidence and a positive outlook on mathematics.

In general, the study results indicate that both variables contribute significantly to mathematics learning success, both separately and in an integrated manner. The study results are presented by highlighting four main focuses that reflect the interconnectedness of the concepts and research findings: spatial literacy skills, mathematical productive dispositions, the relationship between the two, and their implications for mathematics learning.

1. Spacial Literacy Skills

Spatial literacy skills are a crucial factor in supporting the understanding of mathematical concepts, particularly in the context of geometric visualization and reasoning. Spatial literacy is defined as the ability to understand, reason about, and mentally manipulate objects and spatial relationships, both in two and three dimensions (Mas'udah et al., 2021). A literature review found that this skill significantly contributes to helping students understand abstract mathematical concepts through visual representation and spatial manipulation.

Research by Octaria et al. (2024) shows that the application of spatial literacy concepts in geometry learning has a significant impact on student understanding. Through a systematic review, they found that learning strategies involving visualization activities, the use of three-dimensional models, and digital technology can improve students' ability to solve complex geometric problems. This finding is supported by Putri et al. (2025), who, through a systematic review of spatial ability-

based learning trends in Asia, concluded that the integration of explicit spatial learning has an impact on improving student learning outcomes and motivation in mathematics.

In the context of implementing learning media, R. N. Putri & Nurafni (2025) developed a multimedia-based interactive e-book to improve the spatial literacy of elementary school students. Their research findings showed that the e-book, featuring animations, simulations, and exploratory activities, helped students better understand geometric concepts. Meanwhile, Ozcakir & Cakiroglu (2021) designed an Augmented Reality (AR)-based learning toolkit to improve the spatial abilities of middle school students. This medium proved effective in helping students visualize the transformation of objects in space and understand the dynamic relationships between geometric elements.

Herrera et al. (2024) research also supports these findings by showing that the use of digital spatial visualization tools enhances the connection between abstract concepts and concrete experiences. Through software-assisted visualization activities, students can better conceptualize spatial relationships. Xu et al. (2025) research on Chinese students found that spatial reasoning skills contribute significantly to mathematics performance across content domains, particularly in problems requiring the interpretation of complex spatial relationships. Similarly, Schenck & Nathan (2024) emphasized that spatial ability is a fundamental component of mathematics education, and its development should be a primary focus of the 21st-century curriculum.

Research by Harris (2023) highlights that spatial abilities are not only cognitive but also related to the learning context and pedagogical approach used. These abilities develop more optimally when students engage in activities that connect spatial reasoning and mathematical applications. Kustiawati et al. (2023) support this through their research findings, which show that students who received spatial literacy training on geometric transformations had higher representation and visualization abilities than students who learned using conventional approaches.

In general, it can be concluded that spatial literacy skills play a crucial role in strengthening conceptual, representational, and mathematical problem-solving skills. These skills can be enhanced through technology-based approaches, interactive visualizations, and exploratory activities involving direct interaction with spatial objects.

2. Mathematical productive disposition

Mathematical productive disposition is an affective aspect that reflects students' beliefs, interest, persistence, and positive attitudes toward mathematics. Several articles have shown that productive

disposition plays a role no less important than cognitive aspects, as it directly influences students' motivation, self-efficacy, and resilience in facing difficulties in learning mathematics.

Hsieh et al. (2025) examined the relationship between pre-service teachers' dispositions and their ability to recognize pedagogical opportunities in technology-based mathematics learning. The results showed that teachers with positive dispositions were better able to design learning experiences that facilitate active student engagement. Meanwhile, Haji et al. (2019) demonstrated that implementing Realistic Mathematics Education (RME) with an outdoor learning approach improved students' productive dispositions because they perceived learning to be more meaningful and contextual.

Research by Husniah et al. (2021) found a positive correlation between productive disposition and mathematics achievement in madrasah students. Students with a high productive disposition showed greater interest in learning and were more resilient to difficulties in understanding concepts. Awofala et al. (2020) also found similar results in Nigeria, indicating that productive disposition was significantly related to high school student achievement. This means that students with positive beliefs about mathematics tend to achieve higher academic results.

Wilkerson (2021) demonstrated that service-learning activities in mathematics foster a sense of social responsibility and a positive attitude toward mathematics, which are part of productive dispositions. Chua (2022) added that teachers' reflection on their own teaching practices can foster students' productive dispositions, as students see concrete examples of reflective and persistent behavior in the face of adversity. Research by Rahman et al. (2025) also found that the use of GeoGebra in learning not only improves students' strategic abilities but also strengthens productive dispositions through interactive and enjoyable visual experiences.

Furthermore, Rahman (2025) research highlights the role of motivation and self-efficacy as determinants of productive disposition. The results show that students with high self-efficacy tend to be more positive towards mathematics and have a sense of responsibility towards their learning process. Hidayat et al. (2024) added that external factors such as family environment and school support also influence the formation of productive disposition, so the role of the social environment cannot be ignored. Finally, Syahputra (2024) through research on ninth-grade junior high school students found that productive dispositions develop when teachers implement learning that encourages reflection, collaboration, and appreciation for students' thinking processes.

From the overall findings, it can be concluded that a productive mathematical disposition is not simply a positive attitude toward learning, but rather an important indicator of long-term academic success. This disposition can be enhanced through learning that fosters meaning, provides space for self-reflection, and fosters students' confidence in their mathematical thinking abilities. Therefore, strengthening productive dispositions should be an integral part of mathematics learning strategies in schools.

3. The Relationship between Spatial Literacy Ability and Mathematical Productive Disposition

The relationship between spatial literacy skills and mathematical productive dispositions is the primary focus of this literature review. Although most studies examine the two separately, several findings suggest a close relationship between the two in supporting understanding and achievement of mathematics learning outcomes. Conceptually, spatial literacy skills provide a cognitive foundation that helps students understand mathematical structures and representations, while productive dispositions serve as affective factors that maintain motivation and persistence in the learning process.

Atit et al. (2020) investigated the role of spatial ability and motivation on secondary school students' mathematics achievement. The results showed that these two variables influence each other; students with high spatial ability but low disposition do not achieve optimal learning outcomes, and vice versa. These findings demonstrate that spatial ability and productive disposition are not two independent components, but rather mutually reinforcing and interacting in influencing mathematics learning success.

Xu et al. (2025) also found that spatial reasoning contributes significantly to students' mathematics performance, especially when students possess positive dispositions such as curiosity and persistence. Hsieh et al. (2025) added that teachers' dispositions toward mathematics learning technology influence their ability to notice teaching opportunities that develop both spatial abilities and positive student attitudes. This suggests that strengthening the relationship between these two aspects can also be mediated by pedagogical factors.

Rahman et al. (2025) provide a concrete example of the integration of these two aspects through GeoGebra-based learning, where spatial abilities are developed through digital exploration, while productive dispositions are strengthened through students' success in finding their own solutions.

Similarly, Chua (2022) also emphasizes the importance of teacher reflection in fostering both aspects simultaneously, as a reflective approach helps students link spatial thinking skills with positive attitudes toward the learning process. This close relationship is also evident in Harris (2023) research, which explains that spatial abilities and productive dispositions not only contribute to mathematics learning outcomes but also shape reflective and metacognitive thinking. Students with high spatial abilities and positive dispositions demonstrate the ability to assess their own thinking processes and make strategic adjustments when encountering difficulties.

Thus, it can be concluded that spatial literacy skills and mathematical productive dispositions have a strong interactive relationship in influencing mathematics learning outcomes. Both complement each other in the cognitive and affective domains. Students with good spatial skills but without positive dispositions tend to be unable to maintain learning motivation, while students with strong dispositions but weak spatial skills face difficulties understanding abstract concepts. Therefore, effective learning needs to be designed to foster both simultaneously.

4. Implications in Mathematics Learning

The findings from this literature review provide several important implications for the development of mathematics learning in schools. First, mathematics learning needs to be directed towards a balanced integration of cognitive and affective aspects. Teachers need to design learning experiences that foster visualization and spatial reasoning skills through concrete activities such as object manipulation, modeling, or the use of interactive digital media. This approach has proven effective in helping students develop deeper conceptual understanding (Ozcakir & Cakiroglu, 2021; Herrera et al., 2024).

Second, mathematics learning needs to integrate contextual approaches relevant to students' real-life situations. Haji et al. (2019) demonstrated that outdoor context-based learning enhances productive dispositions because students perceive learning activities as meaningful. Similarly, Wilkerson (2021) found that service-learning involving students in social activities fosters a sense of responsibility and a positive outlook on mathematics. Such contextual approaches can simultaneously strengthen spatial abilities, as students learn to understand the relationship between mathematical concepts and their physical environment.

Third, strengthening the relationship between spatial abilities and productive dispositions can also be achieved through reflection-based learning. Chua (2022) emphasized that teacher and student

reflection on the learning process can strengthen spatial understanding and increase self-confidence. Students learn to evaluate their thinking strategies and discover new ways to solve problems. Fourth, external factors such as the family and school environment must also be supportive, as found by Hidayat et al. (2024), because social support influences the formation of positive attitudes and student learning motivation.

Fourth, the results of this study also provide a basis for developing a mathematics curriculum that is responsive to the needs of the 21st century. Spatial literacy skills and productive dispositions are essential competencies that support critical thinking, creativity, and lifelong learning. Therefore, learning evaluation should not only assess cognitive outcomes but also include affective indicators and students' learning attitudes. Ideally, mathematics learning should shape students who not only understand concepts but also have a passion for continuing to learn and apply mathematics in real life.

Overall, the results of this study confirm that spatial literacy skills and mathematical productive dispositions are two inseparable components in modern mathematics learning. Integrating the two will result in a more meaningful learning process, adaptive to change, and oriented toward developing students' full potential. By understanding and applying these findings, teachers can create mathematics lessons that not only enhance students' intellectual development but also foster character, perseverance, and self-confidence, which are the foundation for successful lifelong learning.

4) CONCLUSIONS

Spatial literacy skills and mathematical productive dispositions play a role in the success of mathematics learning. Spatial literacy and mathematical productive dispositions complement each other in supporting the mathematics learning process. Spatial literacy serves as a cognitive foundation that helps students visualize and understand abstract concepts through spatial representation and visual modeling. Conversely, productive dispositions are affective aspects that encourage students' self-confidence, perseverance, and positive attitudes toward mathematical activities. The combination of these two aspects creates a balance between thinking skills and learning attitudes that is crucial for achieving meaningful learning outcomes.

Spatial literacy can be improved through the use of media and technology such as Augmented Reality and GeoGebra, while productive dispositions are fostered through contextual and reflective learning. The two are mutually reinforcing, so mathematics instruction needs to be designed to develop

both aspects simultaneously so that students not only understand the concepts but also develop strong motivation and resilience to learn.

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