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# The use of geogebra interactive multimedia on spatial ability of elementary students in 2020-2024 period

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**Abstract**

*Spatial ability constitutes a critical cognitive skill that facilitates students' capacity to comprehend and manipulate spatial information. In recent years, the integration of technology—particularly interactive multimedia tools such as GeoGebra—has garnered increasing attention as a means to enhance spatial ability among elementary school students. This study presents a literature review examining the effectiveness of GeoGebra in fostering spatial abilities in elementary education between 2020 and 2024. A total of eleven peer-reviewed articles were identified using Harzing's Publish or Perish software in conjunction with Google Scholar. Each study was systematically analyzed, and pertinent data were synthesized into a table summarizing the title, authorship, year of publication, and principal findings. The review indicates that, relative to conventional instructional methods, the use of GeoGebra significantly enhances students' mathematical comprehension. Key trends identified include notable improvements in visualization, mental rotation, and spatial problem-solving abilities among*

*students engaged in GeoGebra-based instruction. The findings underscore the potential of GeoGebra as an effective pedagogical tool for promoting spatial reasoning and conceptual understanding in elementary mathematics education. These insights carry important implications for curriculum development, suggesting that technology-enhanced learning environments can foster greater student engagement and a deeper grasp of geometric concepts.*

## INTRODUCTION

### Background of the Study

Mathematics is one of the subjects given in formal educational institutions, as well as an important component in efforts to improve the quality of education (Novitasari *et al*., 2021). The principle of learning mathematics is based on student abilities, namely the prerequisite abilities needed before students receive learning and the abilities that are the learning objectives. Mathematics has several branches of science, including algebra, geometry, statistics, calculus, and so on (Azmi & Salam, 2022).

Geometry is a branch of mathematics in which it discusses points, lines, planes, and relationships between elements in geometry. The many benefits of geometry make geometry considered interesting to learn (Andriliani *et al*., 2022). Learning mathematics, especially geometry, requires prerequisite skills to facilitate students in learning geometry. One of these prerequisite abilities is spatial ability. Spatial ability is an ability related to shape, shape, space, and the relationship between its elements (Sudirman & Alghadari, 2020)

Spatial ability is one of the important aspects in learning mathematics and science that helps students understand, analyze, and visualize objects in three-dimensional space (Octaviani *et al*., 2021). This ability is the foundation to support mastery of geometry material that requires visual representation. However, the spatial ability of elementary school students in Indonesia is still relatively low, which is caused by the limitations of learning aids that support the visualization of geometry concepts (B. H. Siregar *et al*., 2020).

According to (Franselaa *et al*., 2021) in assessing spatial abilities in students, indicators are needed including: (1) Spatial Perception, students are able to state the actual shape and size of the 3D view based on a certain point of view; (2) Visualization, students are able to state the actual shape of changes in the arrangement of 3D objects; (3) Spatial Relation, students are able to express the relationship between

elements in three dimensions. In addition to paying attention to prerequisite abilities, learning difficulties are also caused by inappropriate learning methods used. So that the learning activities carried out are considered less effective in improving students' abilities

*GeoGebra*, an interactive multimedia-based software, offers features that allow students to visualize and manipulate spatial shapes dynamically. The use of GeoGebra is considered to overcome students' difficulties in understanding abstract geometry concepts and enhance the learning experience (Fazryn *et al*., 2023). Therefore, it is important to evaluate the effectiveness of GeoGebra in improving the spatial ability of elementary school students based on current research. *Geogebra* is an open-source software that functions as a mathematics learning tool with a combination of visualization of geometry, algebra, and calculus (Juandi *et al*., 2021). In its use, *Geogebra* allows students to connect mathematical concepts with real-world applications. With *Geogebra*, students can visualize mathematical concepts more easily and deepen their understanding of the material being studied.

One of the advantages of *Geogebra* is its ability to provide ease in understanding abstract mathematical concepts (Latifi *et al*., 2022). In *Geogebra,* students can access various types of math applications such as graphics, geometry, statistics, calculus, and so on. In its application, *Geogebra* can help students overcome difficulties in understanding abstract mathematical concepts and provide a more interactive learning experience. The utilization of *Geogebra* in mathematics learning can improve students' understanding and mathematical skills. In addition, the use of *Geogebra* can also help students develop cognitive abilities such as critical reasoning, creative thinking, and communication. In learning mathematics, the use of *Geogebra* is highly recommended because it can help students understand mathematical concepts in a more real and fun way.

According to Harahap & Yahfizham (2024) the use of *GeoGebra software* can provide an improvement in students' mathematical abilities and deepen their understanding of mathematical concepts. N. U. Siregar *et al*., (2023) found that the application of *GeoGebra* in learning mathematics gave more positive results. In addition, Pratama *et al*., (2023), showed how to develop interactive media with line and angle material with the help of *GeoGebra* using a model commonly referred to as 4D, consisting of: definition, design, development, and distribution. It is also helped

from the assessment of material experts, media experts, and student responses determine the validity and usefulness of this tool.

In learning geometry, it is important to pay attention to unique concepts, the development of students' thinking, the essential properties of materials, and how they are applied in everyday life. In teaching geometry, teachers need to follow the general principles of teaching, namely starting from concrete to abstract, from simple to complex, and from easy to difficult. Based on Piaget's theory, grade 1 students transition from pre-operational stage to concrete operational stage, while grade 6 students transition from concrete operational stage to formal operational stage. Most students in primary school are in the concrete operational stage. Thus, children's abilities vary from class to class. Therefore, in geometry lessons, teachers must adjust to the abilities of each student.

Geometry is an important part of mathematics that must be understood by students. Geometry concepts are very relevant to everyday life. Learning geometry aims to improve logical thinking skills, strengthen spatial intuition, provide a foundation for other subjects, and be able to interpret mathematical arguments. This is because students already know about lines, planes and spaces before they start school. However, evidence shows that the ability to learn geometry is still not good enough. In fact, many students still have difficulty learning math, especially math related to interrelated geometry. Difficulties in one part of geometry can have an impact on difficulties in other parts of geometry.

## The Problem of The Study

According to Rahmadita *et al*., (2024) Mathematics learning in the Merdeka Curriculum aims to develop students' independence, critical thinking skills, and creativity through materials such as geometry. This curriculum emphasizes the importance of students understanding the concepts learned rather than just memorizing, including in learning mathematics in elementary school.

This study analyzed 11 articles that discussed the use of *GeoGebra* in improving students' mathematical spatial abilities, especially at the elementary school level. The articles in the analyzed research obtained various methods and approaches, including the scientific approach, project-based learning, and the use of *GeoGebra-based* learning videos. In contrast to previous research that focused on one particular type of method or approach, so it lacks the variety and richness of methods that can be used with *GeoGebra*. In the era of the Industrial Revolution 4.0, the ability to utilize

technology in education is very important. *GeoGebra* as a technology-based learning tool can help students prepare for future challenges.

With the help of technology, it can facilitate teachers in providing learning space for students. The utilization of *GeoGebra* software or applications as a mathematics learning media with various facilities is one example of how existing technology should be utilized as effectively as possible, especially in the teaching and learning process. The presence of dragging animation facilities provides a clearer visual experience to students in capturing geometry concepts Azkiya *et al*., (2023). The use of *Geogebra* Application in learning mathematics on the material of surface area and volume of cubes will provide direct experience for students in knowing the length of the cube ribs affects the surface area and volume of the cube. Because in the *Geogebra* Application it will be clear that if the length of the cube rib is increased, the cube image will enlarge, so that the derivation of the formula for finding the surface area and volume of the cube will be easier for students to understand and understand.

Some previous studies conducted by Rohmatunnisa *et al*., (2022), Wulansari *et al*.,(2022), Aurellia & Harahap, (2024), Rhilmanidar *et al*., (2020) have shown the effectiveness of applying *Geogebra* Application Media in learning flat-sided space building material. Based on the results of the two studies, the use of *Geogebra* Application Media in learning can improve student learning outcomes.

## Research's State of the Art

Recent research shows that *GeoGebra* has been widely used in mathematics learning at various levels of education. In the period 2020-2024, many studies reported the positive impact of *GeoGebra* on students' spatial abilities in geometry concepts. Some studies also noted that the use of *GeoGebra* increased student learning motivation due to its interactive visual approach Nurhikmah *et al*., (2023). The development of science and technology can have an impact on the creation of interactive learning media. According to Muliyana (2022), that interactive learning media is a means or tool in learning activities where teachers and students interact with each other between recipients and providers of information or material that can indeed be understood by both parties. Interactive learning media can be in the form of software that is compiled as well as possible so that it can be used in the classroom. However, currently teaching and learning activities involving computer-based media have not been fully utilized evenly, seeing the condition of education in Indonesia there is still a lack of facilities and infrastructure

The improvement of mathematical spatial ability in students who follow guided discovery learning with the help of *GeoGebra* is more significant than students who follow conventional learning and the use of *problem-based* learning tools supported by *GeoGebra* in teaching space building materials has a significant impact on improving students' spatial abilities.

The research's state of the art is literature Reviews that examine the pertinent contributions to the existing literature. A literature review should identify the theoretical foundation of a study, the level of originality and significance of the research, and help clarify and refine the focus, research questions, and hypotheses to be discussed. Additionally, the literature review must justify the research focus.

## Novelty, Research Gap, & Objective

This literature review has prominent novelty in several aspects: 1). Analysis of the 2020-2024 Period: This study integrates the latest findings from that time span, which includes the latest innovations in *GeoGebra* implementation for geometry learning at the elementary school level. Most previous studies did not limit the time scope so the results of the analysis tend to be more general (Ariyani *et al*., 2022), 2). Focus on Spatial Ability of Spatial Buildings in Elementary School: While many previous studies discuss *GeoGebra* in general or its application at the secondary and higher education levels, this research specifically explores the spatial abilities of elementary school students related to the concept of spatial construction. This makes a unique contribution in understanding the effectiveness of GeoGebra at an age when children are still in the concrete-operational stage of cognitive development (Novitasari *et al*., 2021), 3). Contextual Perspective in Indonesia: This research also considers the educational context in Indonesia, such as access to technology, teacher competence, and local curriculum, which often receive less attention in the international literature.

Nayanti *et al*., 2023 revealed that *Geogebra* can help teachers in delivering learning materials to make them easier to understand, because Geogebra can display clear visuals, besides that Geogebra can also increase students' creativity and critical thinking. Thus the use of Geogebra as a learning media can train students to solve problems independently through object visualization so that understanding of mathematical concepts is easier to digest.

Most previous studies have only evaluated the effectiveness of GeoGebra at the intermediate or advanced levels (Rhilmanidar *et al*., 2020), while research specifically

exploring the spatial abilities of elementary students is still limited. In addition, there is no literature review that integrates the latest findings from the 2020-2024 period to provide a comprehensive picture of GeoGebra's influence on elementary students' spatial abilities.

Spatial ability is key in improving the understanding of geometry concepts in elementary school students. The use of technology-based learning media such as *GeoGebra* can help students visualize geometric objects, thus improving their spatial skills. *GeoGebra* as an interactive tool allows students to transform, rotate, and manipulate geometric objects in a digital environment, so that students can better understand the spatial relationships between objects (Lutfi M. K., 2024). Other research also shows that students who use *GeoGebra* have a better level of concept understanding compared to students who use conventional methods without technological assistance (Sudiman A. *et al.,* 2023).

During the period 2020 to 2024, research on the effect of interactive multimedia, especially *GeoGebra*, in learning geometry at the elementary school level showed mixed results but tended to be positive. Research conducted by (Lestari, et al 2023) confirmed that the use of *GeoGebra* increased students' interest in learning as well as their ability to solve geometric problems. This is in line with the findings of (Siregar N. U., et al 2023) which show that *GeoGebra* integration can improve students' understanding of the concepts of space and shape, and facilitate their understanding of geometric transformations.

However, some studies have also found challenges in implementing this model. For example, Daroini A. F. *et al.* noted that teachers' level of readiness to use technology, as well as limited access to digital devices, can hinder optimal implementation. In addition, factors such as the time required to master the software, as well as the need for further training for educators are also obstacles to the implementation of *GeoGebra-assisted* learning models.

From the literature review that has been conducted, *GeoGebra* has great potential in improving the spatial abilities of elementary school students. However, effective implementation requires strong support from various parties, including increasing teacher competence in utilizing educational technology. Therefore, further research needs to be done to optimize the use of *GeoGebra* in learning that focuses on spatial abilities, as well as to overcome the obstacles that arise during the learning

process. *GeoGebra* allows users to perform construction with various mathematical spatial objects (Fikru Gurmu, 2024).

## METHOD

### Type and Design

The writing in this study uses the literature review method with the aim of analyzing and identifying the effect of using *GeoGebra* interactive multimedia on the spatial abilities of elementary school students. Literature research involves literature study and analysis of relevant topics and data collection from various sources such as journals, books, dictionaries, documents, magazines, and others. This process does not require field studies (Mendes *et al*., 2020).

Researchers took 11 articles that discussed the use of the *GeoGebra* program used to improve students' mathematical spatial understanding skills. The selection of articles was based on high relevance to the research topic, namely the use of *GeoGebra* in improving students' mathematical spatial understanding, by limiting the number of articles researchers can focus more on in-depth analysis of the most relevant and significant studies. These articles were selected from national journals, including results from *Google Scholar*, published between 2020 and 2024 using *Harzing's Publish or Perish* application. Each article was analyzed, and a table containing the title, author name, year of publication, and research findings was created. In conclusion, these articles were compared to explore and compare relevant findings.

### Data and Data Sources

Data from this literature review are obtained from various relevant and credible literature sources, such as scientific journals, research articles, reference books, and various educational journals that have been published within a period of four years or the period 2020 to 2024. The primary data source taken from this literature review is the results of previous research in which it examines how the implementation of differentiated learning in elementary schools, both domestic journals and journals from abroad. This literature study is descriptive-analytical, where researchers describe the findings in the literature and analyze them to identify patterns, themes, and research gaps. By using this approach, the research can contribute a holistic view of the effectiveness of GeoGebra in learning geometry at the primary school level.

## Data Collection Technique

Data collection techniques in this writing are carried out through systematic steps to ensure the relevance, credibility and quality of the sources used. The techniques used include: Literature search of articles conducted through reputable academic platforms and databases such as Google Scholar for general article access and proceedings and Harzing's Publish or Perish.

The keywords used in the search include: GeoGebra, spatial ability, elementary students, geometry learning, and interactive multimedia. Inclusion and Exclusion Criteria Articles found were screened based on the Inclusion Criteria published in the period 2020-2024, focusing on the use of GeoGebra for geometry learning at the elementary level. Empirical studies with clear research methods. Articles in English or Indonesian. Furthermore, the Exclusion Criteria: Articles that are not relevant to the research objectives, studies that only discuss GeoGebra at the junior or senior high school level without relevance to elementary school, articles that do not provide full access to the text.

Initial screening of articles found through the literature search was analyzed based on title and abstract to determine relevance. Introduction, methods, and results to ensure appropriateness to the focus of the study. Final data collection articles that met all inclusion criteria were collected and organized in reference management software such as Mendeley to facilitate analysis.

## Data Analysis

The data that has been collected from various literature sources is packaged and analyzed in depth to identify important things related to the use of Geogebra interactive multimedia on the Spatial Ability of Elementary Students for the 2020-2024 period. The research begins by looking for articles related to the research topic to be carried out. One of the criteria for scientific articles used as data is scientific articles sourced from international and national journals. The time span used is the last 4 years, namely from 2020-2024. In the initial stage of searching for journal articles, the author obtained 200 articles through the search keyword "Use of Geogebra Interactive Multimedia on Spatial Ability". The next stage is to validate scientific articles by grouping scientific articles based on the title of the article in accordance with the idea of the topic raised. Then the next step is to review the quality of the available scientific articles whether they are relevant to the research topic. Based on the results of the analysis of the available literature, from 200 articles which

were then selected as many as 11 articles, several main findings were found related to the use of Geogebra on the spatial abilities of elementary school students.

## RESULTS

The results of a review of some literature related to the use of Geogebra interactive multimedia on the spatial abilities of elementary school students show an improvement in both the process and learning outcomes. However, of course there are challenges and difficulties faced by teachers and students when implementing differentiated learning in the classroom. Analysis of research articles on the use of GeoGebra interactive multimedia on students' spatial abilities in mathematics learning is shown in Table 1**.**

**Table 1.** Article Research Data Related to the Use of *GeoGebra* Interactive Multimedia and Spatial Ability

| Title | Author and Year of Publication | Research Results |
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| Integration of Augmented Reality assisted by Geogebra as an Interactive Learning Media in Learning Spatial Buildings Material | Lutfi & Kusumastuti, (2024) | The results of this study that the utilization of Augmented Reality Geogebra in the learning process can help students in spatial thinking. This research approach was conducted quantitatively using the Paired-Sample T Test. The results of the study showed that there was a significant difference in student learning outcomes on the PreTest and Post Test after they used AR Geogebra media on Spatial Buildings Material. AR Geogebra technology can help students recognize |

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| | | spatial shapes. Overall, this research shows that AR Geogebra interactive media can be integrated in learning Spatial Buildings. |
| Augmented Reality (AR) on Geogebra Improves the Ability of Spatial and Mathematical Problem Solving on the Material of the Third Dimension | Herman *et al*., (2023) | The results of this study show AR enhances the learning experience by integrating two-dimensional and three-dimensional objects into the real environment, making learning more interactive and engaging for students. The technology supports various factors such as sensing, registration, interactivity, and display systems, which are crucial for effective learning. This study highlights that the use of AR can positively influence students' spatial abilities and problem-solving skills in mathematics. This is particularly relevant for geometry, where visualizing concepts can be challenging for students. |
| Development of Geogebra Software-Based Learning Media on Cube Material to | Raharjo *et al*., (2023) | This research suggests that educators should incorporate GeoGebra-based media not only for |

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| Develop Students' Spatial Ability | | teaching cubes but also for other math concepts. This approach can further improve students' spatial reasoning and overall understanding of geometry. The use of interactive media significantly increases students' motivation and engagement in learning geometry. The study highlights that students find Geogebra software more engaging compared to traditional teaching methods, which often lack visual aids. |
| Development of Geogebra Transformer Application Based on Mathematical Spatial Ability | Ariyani *et al.*, (2022) | The study found that students have low interest in math, especially during online learning. The GeoGebra Transformer app aims to address this issue by making learning more engaging. The limited test results showed that 78.9% of students responded positively to the app, indicating an increase in student engagement, the study concluded that the GeoGebra Transformer app is valid and practical to enhance the learning |

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| | | experience in the topic of geometry transformation. It effectively integrates mathematical spatial ability into its design, making it a valuable tool for educators. |
| Geogebra as a Learning Support And Improved Spatial Ability | Novianti *et al*., (2024) | The results showed that the utilization of GeoGebra has a positive impact on improving students' spatial abilities. This suggests that integrating this technology into learning can lead to better educational outcomes in terms of spatial understanding, The study highlights that GeoGebra is not only effective but also more efficient in improving spatial skills compared to traditional teaching methods. This efficiency can be attributed to GeoGebra's interactive and visual nature, which helps students understand complex spatial concepts more easily. |
| Application of Geogebra Application in Mathematics Learning | N. U. Siregar *et al*., (2023) | The study used a quasi-experimental design with a one-group pre-test and post-test approach. This design allowed a clear comparison of students' |

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| | | critical thinking abilities before and after the intervention with GeoGebra, During the learning process, students showed increased engagement and participation. They actively expressed their opinions, sought solutions to problems, and discovered new knowledge, which contributed to the development of their critical thinking. |
| Improving Spatial Ability through the Application of Van Hiele's Theory Integrated with Multimedia Considering Students' Learning Styles | B. H. Siregar *et al.*, (2020) | The study investigated the effectiveness of Van Hiele's Theory integrated with multimedia in improving students' spatial ability, especially focusing on different learning styles. The study found that students who were taught using Van Hiele's Theory integrated with multimedia showed significant improvement in spatial ability compared to those who received instruction through direct teaching methods. This suggests that the multimedia approach, when combined with Van Hiele's Theory, is more |

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| | | effective in improving spatial skills. |
| Improvement of Students' Mathematical Spatial Ability Through Guided Discovery Model Assisted Geogebra | Rahman & Saputra, (2022) | The study concluded that students who engaged in guided discovery learning with GeoGebra showed better improvement in their mathematical spatial abilities compared to those who experienced conventional learning methods. These findings emphasize the importance of innovative teaching strategies in mathematics education, the results of this study highlight the potential benefits of using technology and guided discovery methods in improving students' understanding and skills in mathematics, especially in spatial reasoning. |
| Development of Learning Tools for Geometric Buildings Geogebra-Assisted Space to Improve Spatial Ability of Elementary School Students | H. A. Sari *et al*., (2022) | This study successfully developed learning tools that include Lesson Plans (RPP), Student Worksheets (LKS), and spatial ability tests. These devices were validated, practical, and effective, with validity coefficients of 3.80 for the lesson plan, 3.53 for the LKS, |

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| | | and 3.58 for the spatial ability test, the use of computer-based learning media, such as GeoGebra, was found to increase students' interest and motivation in learning geometry. This is in line with the growing trend of integrating technology into education to improve learning outcomes. |
| How to Develop Spatial Skills in Mathematics Learning in Schools? A Literature Review | Sudirman & Alghadari, (2020) | This research identified three main categories of spatial ability: The ability to accurately understand spatial relationships, the capacity to visualize and manipulate objects in space, the skill to mentally rotate objects to understand their orientation. The findings emphasize that spatial ability development should be integrated into the mathematics curriculum, especially in geometry, to ensure that students can apply these skills effectively in various contexts. |
| Systematic Literature Review (SLR): Utilization of | Lestari *et al*., (2023) | This article comprehensively analyzes the utilization of GeoGebra |

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| Geogebra Software in Mathematics Learning | software in mathematics education over the past decade. The frequency of publications regarding the use of GeoGebra in mathematics education has shown fluctuations over the past ten years, with a notable peak in 2020, where 18 articles were published. The software is predominantly used in secondary and higher education settings. However, there is a lack of research focusing on its application in primary education. This indicates a gap in the literature that could be further explored, GeoGebra has been effectively applied in the teaching of various mathematical topics, especially in geometry and algebra. This versatility makes it a valuable tool for educators looking to improve their teaching methods. |

## DISCUSSIONS

Table 1. shows some research on the use of GeoGebra Interactive Multimedia and Spatial Ability, using the GeoGebra program as an indicator of diverse materials.

GeoGebra learning media is proven to be effective in teaching various mathematical materials such as geometry transformation, flat building, space building, algebra, and dimension three. The results of research conducted by Lutfi & Kusumastuti, (2024) showed that the Paired-Sample T Test showed a difference in the average student learning outcomes on the Pre Test and Post Test which was observed from the Sig value. (2-tailed) of 0.000 which is less than 0.05. After further observation of the average student learning outcomes, there is an increase in the average where the Pre Test obtained a value of 51.00 while the Post Test obtained a value of 79.83. The implication of the integration of Augmented Reality assisted by Geogebra in the learning media of building space material is that students are facilitated in thinking spatially including in recognizing the object of building space. Therefore, students more easily understand the shape of space and have an impact on improving their learning outcomes. By utilizing the interactive and immersive features of AR Geogebra, educators can create an engaging learning environment that encourages active exploration and visualization of spatial shapes, which ultimately enriches students' learning experience in learning geometry.

Herman *et al*., (2023) show that the use of learning media with Augmented Reality (AR) is effectively used in learning because students can see in real time and directly imagine the results of the learning process. Augmented Reality learning media helps students visualize abstract concepts for understanding and the structure of an object becomes more effective. The use of Augmented Reality (AR) learning media through applications such as Geogebra can improve spatial abilities and problem solving skills. The suggestion of this research is the need to hold training in the use of Augmented Reality (AR) based learning media because until the time this paper is made, there are still many teachers who do not know the presence of Augmented Reality technology and mathematics learning applications even though learning using AR is proven to improve spatial abilities and problem solving so that learning objectives will also be achieved.

In addition, Raharjo *et a*l., (2023) showed that the development of Geogebra software-based media in this study has met the validation criteria, is practical for use in learning activities, and achieves good effectiveness criteria in learning, so that it can be accepted by students and can be utilized as a learning medium, especially cube material. Based on the results of the study, this Geogebra software-based media is suitable for use to support mathematics learning activities. Based on this, it is

recommended that educators utilize Geogebra software-based media in learning activities, especially on cube material, so that students' spatial abilities can be empowered. Regarding further development, it is necessary to develop learning media with a similar concept, namely Geogebra-based mathematics learning media for other materials, and not only limited to cube material. The quality of Geogebra software-based learning media can be seen from three aspects, namely validity, practicality, and effectiveness.

Ariyani *et al*., (2022) This research and development produces products in the form of android-based learning media, namely the GeoGebra Transformer application. The stages taken to produce the GeoGebra Transformer application are analyse, design and development which consists of preliminary study analysis, needs analysis, application design, application development, application validation, limited test and application practicality test. The material contained in the GeoGebra Transformer application is in the form of geometric transformations integrated with GeoGebra and based on mathematical spatial abilities integrated in the exploration menu. Based on the validation of material experts and media experts both obtained a score of 3.3 with valid criteria. Limited test results with teachers and students get a good response to the GeoGebra Transformer application. Based on the results of the practicality test on the teacher's assessment obtained a score of 3.4 with practical criteria and student assessment with a score of 3.1 with practical criteria. In addition, 30 students or 78.9% gave a positive response to the application. So it can be concluded that the GeoGebra Transformer application is valid and practical so that it can be used in learning mathematics.

Novianti *et al*., (2024) that the use of GeoGebra has a positive, effective, and more efficient impact in improving the spatial abilities of students. By using GeoGebra, teachers have the opportunity to develop various learning media that can support the learning process, so that students' spatial abilities can develop more optimally. Research by N. U. Siregar *et al*., (2023) from the results of the research that has been done it can be concluded that students' understanding of geometry concepts will be better if taught GeoGebra compared to conventional learning (expository). In addition, it can also be concluded that there is no significant interaction effect assisted by GeoGebra and students' spatial abilities on students' understanding of geometry concepts. Since the GeoGebra strategy is effective in improving students'

understanding of geometry concepts, it is recommended to mathematics teachers to consider using GeoGebra in learning mathematics, especially in learning geometry.

B. H. Siregar *et al*., (2020) based on the research findings, it can be concluded that there is a significant increase in spatial abilities for students who learn by applying van hiele theory integrated with multimedia compared to direct learning. In addition, there is an interaction effect between learning models and learning styles on students' spatial abilities. The results showed that van hiele theory had a better impact on students with visual learning styles compared to auditory and kinesthetic learning styles to improve mathematical spatial abilities. This was followed by students with auditory and kinesthetic learning styles.

Rahman & Saputra, (2022) In this study, the test of students' mathematical spatial abilities, both ordinary classes and guided discovery classes were carried out twice, namely before the learning took place and after the learning was completed. The data from this study were then compared and analyzed through statistical testing. The average initial test scores of guided discovery class and regular class were 17.74 and 10.55, respectively. The difference in the average score of the initial test of the two classes is 7.19, this means that it is assumed that the initial ability of the two classes is not significantly different because the difference in the average score of the two classes is not much different. While the average gain score of guided discovery class and regular class is 0.75 and 0.42 respectively. The difference in the average gain score of the two classes is 0.33, this means that it is suspected that the improvement in the ability of the two classes in mathematical spatial is significantly different. When looking at the average gain score, it is assumed that there is a significant difference in the improvement of the mathematical spatial ability of the guided discovery class with the mathematical spatial ability of the ordinary class.

Furthermore, research from H. A. Sari *et al*., (2022) that spatial ability in the experimental class is greater than the trial class and the trial class is greater than the control class. The results of the development research conducted by GeoGebra-assisted learning devices on the subject of building space in grade VI elementary school students consisting of Learning Implementation Plans (RPP), Student Worksheets (LKS), and Learning Outcomes Tests (THB). The results of learning devices on the subject of building space with the help of GeoGebra and its effect on students' spatial abilities meet the quality criteria and feasibility of developing learning devices that have been determined, namely meeting the criteria of validity,

effectiveness, and practicality. From the results of the one-way Anova test there is a significant difference in the three classes, the significance value is smaller then H0 is rejected while H1 is accepted. Thus, it can be concluded that there is a significant effect of GeoGebra-assisted problem-based learning learning tools on the material of building space on students' spatial abilities. Suggestions submitted based on the results of the study, learning tools that have been developed can be used as an alternative learning resource by teachers and can be tested in other classes or schools as a follow-up to the development.

Sudirman & Alghadari, (2020) found many ways to develop spatial skills, especially in schools. Spatial abilities can be developed from early education levels to higher education. Based on the literature review of this research, there are at least six ways to develop spatial abilities in learning mathematics at school including: (1) using spatial language in daily interactions; (2) teaching sketches and drawings; (3) using suitable games; (4) using tangrams; (5) using video games; (6) using origami and folding paper. In addition, research from Lestari et al., (2023) Research and publications regarding the use of GeoGebara software in learning Mathematics have been widely carried out. The frequency of publications regarding the use of GoeGebra in learning Mathematics over the past ten years has fluctuated. The most publications occurred in 2020. GeoGebra software can be utilized or used especially in Geometry and Algebra materials and other materials. The utilization of GeoGebra software has been widely done both at the high school and college levels. However, it has not been utilized for elementary school level. The use of GeoGebra can not only improve learning outcomes and learning completeness in mathematics, but also improve students' higher order thinking skills (HOTS). GeoGebra software has been utilized in various regions in Indonesia, especially Western Indonesia. Furthermore, the development of GeoGebra software in learning Mathematics has been widely carried out. Therefore, the use of GeoGebra software in learning Mathematics is highly recommended.

## CONCLUSION

Based on the literature analysis of studies conducted between 2020 and 2024 concerning the use of GeoGebra interactive multimedia to enhance elementary school students' spatial abilities, it is evident that GeoGebra is an effective tool in supporting the development of spatial reasoning, particularly within the context of three-

dimensional geometry instruction. The software's capabilities in 3D visualization and interactive manipulation facilitate students' comprehension of geometric concepts such as dimensions, volume, and the spatial relationships among components of three-dimensional shapes. By transforming abstract mathematical concepts into more tangible representations, GeoGebra aligns well with Piaget's theory of cognitive development, particularly the concrete operational stage, wherein learners benefit from hands-on and visual experiences. Moreover, the integration of GeoGebra into classroom instruction has been shown to enhance student motivation and engagement. The dynamic and interactive nature of the platform fosters a more stimulating learning environment, encouraging active participation and contributing to a deeper understanding of geometric content.

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