

The Effect of Google Sites on Elementary Students' Conceptual Understanding in Mathematics

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Abstract: The advancement of digital technology has transformed primary education, particularly in geometry learning, which relies heavily on visual-spatial skills. This study aims to examine the influence of Google Sites compared to e-books, as well as the role of visual-spatial intelligence, on fourth-grade students' understanding of area and volume concepts. A quasi-experimental method with a 2x2 factorial design was employed, involving 62 students from SDN Losari, Jombang. The research instruments were validated and found to be reliable. Two-way ANOVA results indicated that both learning media and visual-spatial intelligence significantly affected students' conceptual understanding ($p < 0.05$), with a significant interaction between the two variables. Students with high visual-spatial intelligence who used Google Sites achieved the highest learning outcomes. These findings highlight the effectiveness of interactive digital media and the importance of aligning instruction with students' cognitive characteristics. It is recommended that teachers integrate web-based tools like Google Sites, especially for topics requiring spatial visualization, to foster more adaptive and meaningful learning experiences.

Article History

Received: 15-07-2025

Published: 31-10-2025

Key Words :

Google Sites, Visual-Spatial Intelligence, Conceptual Understanding, Digital Learning Media, Elementary Education

How to Cite: Riyanto, H. W., Degeng, I. N. S., & Sitompul, N. C. (2025). The Effect of Google Sites on Elementary Students' Conceptual Understanding in Mathematics . *Jurnal Teknologi Pendidikan : Jurnal Penelitian Dan Pengembangan Pembelajaran*, 10(4), 840–850. <https://doi.org/10.33394/jtp.v10i4.18212>



<https://doi.org/10.33394/jtp.v10i4.18212>

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Introduction

The rapid advancement of digital technology over the past two decades has transformed various aspects of life, including education. Today's education system is required not only to rely on conventional methods but also to integrate technology into the teaching and learning process to meet the needs of the digital generation (Salsabila et al., 2023, p. 45). One form of this integration is the use of digital media, which enhances both the effectiveness and efficiency of learning activities, especially in subjects with abstract characteristics such as mathematics. In the context of elementary mathematics education, the use of digital learning media such as Google Sites and e-books has become increasingly relevant due to their accessibility and flexibility in delivering content.

Google Sites, as a web-based learning medium, offers the advantage of presenting interactive content, including two- and three-dimensional images, simulations, videos, and visual quizzes. This media not only enriches students' learning experiences but also allows them to develop a more concrete and in-depth understanding of mathematical concepts (Salasa et al., 2023, p. 102). Research by Mulyaningsih et al. (2023, p. 88) also shows that

Google Sites can improve learning independence and ease access to information for elementary school students. Conversely, e-books offer advantages in terms of systematic material organization but are limited in visual and manipulative exploration—an important aspect of geometry learning.

In contemporary mathematics education studies, geometry is a topic that demands high visual and spatial skills from students. This is closely related to visual-spatial intelligence, defined as an individual's ability to visualize spatial relationships between objects and to accurately understand forms and space (Nuraini et al., 2022, p. 76). Gardner (2007, p. 113) explains that visual-spatial intelligence involves the ability to recognize direction, size, color, and shape, and to mentally manipulate them. Fathoni (2013, p. 54) outlines four indicators of visual-spatial intelligence: pattern recognition, conceptualization, problem-solving, and imagination. These four indicators serve as the foundation for evaluating how students understand and apply visual concepts, particularly in the topics of area and volume.

Although the use of digital media such as Google Sites and e-books has been widely researched, there remains a gap concerning how individual characteristics, such as visual-spatial intelligence, may moderate the effectiveness of these learning media. Previous studies have largely focused on the general impact of digital media on learning outcomes without considering students' specific cognitive factors. Furthermore, few studies have directly compared the effectiveness of Google Sites and e-books in improving conceptual understanding of area and volume—topics that heavily rely on students' visual-spatial abilities.

This study seeks to address this gap by offering both theoretical and practical contributions. Theoretically, this study integrates technology-based learning media with student characteristics—specifically visual-spatial intelligence—as a moderating variable in mathematics learning. Practically, the findings are expected to provide strategic recommendations for teachers in selecting the most effective learning media tailored to elementary students' characteristics, particularly in teaching spatial concepts such as area and volume.

Based on the above background, this study aims to answer the following research questions: (1) Is there a difference in students' understanding of area and volume concepts between those who use Google Sites and those who use e-books? (2) Does students' level of visual-spatial intelligence influence their understanding of area and volume measurement concepts? (3) Is there an interaction between the type of learning media and the level of visual-spatial intelligence in influencing conceptual understanding of area and volume?

The objectives of this study are to analyze differences in conceptual understanding between student groups based on the type of learning media used (Google Sites vs. e-book), to examine the influence of visual-spatial intelligence levels, and to test the possible interaction between media types and visual-spatial intelligence. Through this approach, the study aims to gain a more comprehensive understanding of the effectiveness of learning media tailored to students' cognitive characteristics.

This research carries both theoretical and practical significance. Theoretically, it is expected to enrich the discourse on technology integration in mathematics education and contribute to the development of learning models that consider individual learner characteristics, particularly visual-spatial intelligence. Practically, it provides a foundation for teachers to design adaptive, relevant, and impactful digital learning experiences that enhance

elementary students' conceptual understanding in mathematics, especially regarding area and volume measurement.

Research Method

This study employed a quantitative approach using a quasi-experimental design. The research design adopted was a 2 x 2 factorial design, which enabled the researcher to examine two independent variables and one moderating variable, as well as their interactions, in relation to the dependent variable. The independent variables were the learning media (Google Sites and e-book), while the moderating variable was the level of visual-spatial intelligence (high and low). The dependent variable in this study was students' conceptual understanding of area and volume measurement. This approach was selected due to the practical constraints that prevented full randomization of participants. Therefore, a nonequivalent control group design was used, consisting of two experimental groups with structured treatment allocations based on the factorial design.

The study was conducted during the second semester of the 2024/2025 academic year, from March to May 2024. The research site was SD Negeri Losari, located in Ploso District, Jombang Regency. This school was selected based on the similarity in facilities, teacher competence, and school readiness to implement digital learning media.

The population of the study consisted of all fourth-grade students at SD Negeri Losari. A purposive sampling technique was employed to select two classes: Class IV A with 32 students and Class IV B with 30 students. Class IV A received instruction using Google Sites, while Class IV B used e-books. Each group was further classified into high and low levels of visual-spatial intelligence based on a preliminary test administered before instruction. The following is the procedure of this research.

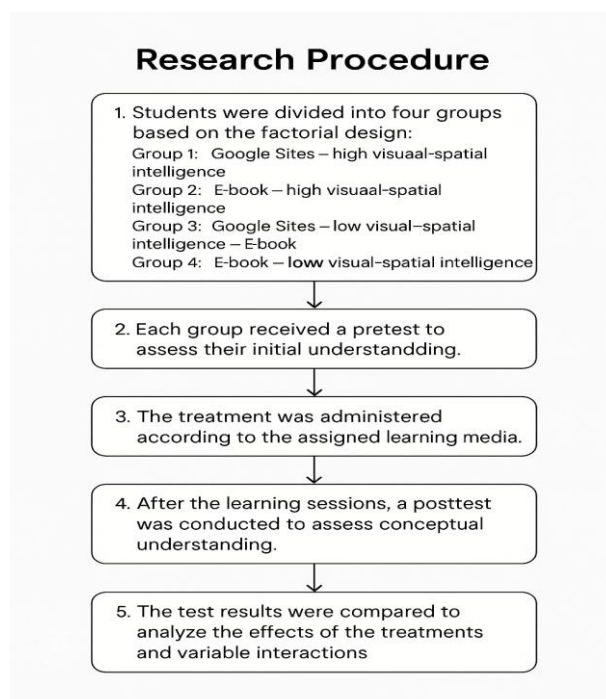


Figure 1. Research Procedure

Data were collected using two types of tests: (1) A multiple-choice conceptual understanding test on area and volume, developed based on fourth-grade learning indicators; and (2) A visual-spatial intelligence test adapted from the Spatial Intelligence Measurement Test by Mulyadi et al. (2018). The conceptual understanding test was administered before and after the learning sessions, while the visual-spatial intelligence test was conducted prior to the intervention. All test items were developed according to students' characteristics and grounded in visual and spatial learning theories.

Instrument validity was tested using two approaches: content validity and construct validity. Content validity was ensured through expert judgment from specialists in mathematics education and psychology. Construct validity was analyzed using factor analysis based on pilot testing. Reliability testing was conducted using the KR-20 formula for the conceptual understanding test and Cronbach's Alpha for the visual-spatial intelligence test. A reliability coefficient of ≥ 0.7 was considered acceptable to ensure the instruments' reliability.

Data analysis was carried out in several stages. The first stage involved descriptive analysis to examine the mean, standard deviation, and score distribution for the pretest and posttest in each group. The second stage involved assumption testing, including normality tests (using Kolmogorov-Smirnov or Shapiro-Wilk) and homogeneity tests (using Levene's Test). The third stage involved hypothesis testing using Two-Way ANOVA to determine: 1) The main effect of the learning media (Google Sites vs. e-book), 2) The main effect of visual-spatial intelligence levels (high vs. low), and 3) The interaction effect between learning media and visual-spatial intelligence on students' conceptual understanding of area and volume.

The ANOVA results were interpreted based on significance values. If the significance value was < 0.05 , it was concluded that there was a statistically significant difference in the examined variable. These results served as the basis for answering the research questions, testing the hypotheses, and formulating practical recommendations for selecting appropriate learning media based on students' cognitive characteristics. This study was conducted over three months, from March to May 2024. The activities included instrument development and validation, administration of the pretest, implementation of the learning interventions, administration of the posttest, and data analysis. The research was carried out in accordance with the academic calendar for the second semester of the 2024/2025 academic year.

Result and Discussion

Results

This study aimed to examine the effect of using Google Sites compared to e-books as learning media, as well as the role of visual-spatial intelligence on fourth-grade elementary students' conceptual understanding of area and volume. Data analysis was conducted based on the results of the visual-spatial intelligence test, pretest and posttest on conceptual understanding, and a two-way ANOVA statistical test.

Before the instructional implementation, students from two classes participating in the study were administered a visual-spatial intelligence test. The test results indicated that students in both the Google Sites group (Class 4A) and the e-book group (Class 4B) exhibited varying levels of visual-spatial intelligence. These scores were used to classify students into two categories: high and low.

Data processing using SPSS revealed that all items in the visual-spatial intelligence test had valid inter-item correlations and high reliability, with a Cronbach's Alpha coefficient

of 0.792. This indicates that the instrument was appropriate for accurately measuring students' visual-spatial intelligence, as presented in Table 1.

Table 1. Validity and Reliability Results of the Visual-Spatial Intelligence Test

Indicator	Corrected Item-Total Correlation	Validity
S1–S12	0,556 – 0,749	Valid
Cronbach's Alpha Total	0.792	Reliable

A pretest was administered to assess students' prior knowledge of area and volume concepts. The average pretest score for the Google Sites group was 70.06, while the e-book group scored 68.53. Normality and homogeneity tests confirmed that the data were normally distributed and the variances between groups were homogeneous, allowing for the application of parametric testing, as shown in Table 2.

Table 2. Students' Pretest Average Scores

Class	Pretest Mean Score
4A (Google Sites)	70,06
4B (E-Book)	68,53

Following the instruction using the respective media, a posttest was administered to measure gains in conceptual understanding. The average posttest score in the Google Sites group increased to 81.17, while the e-book group reached 70.58. These results suggest a more significant improvement in students who learned using Google Sites, as shown in Table 3.

Table 3. Students' Posttest Average Scores

Class	Posttest Mean Score
4A (Google Sites)	81,17
4B (E-Book)	70,58

A two-way ANOVA was conducted to examine the effects of learning media, visual-spatial intelligence, and the interaction between them on conceptual understanding. The test results indicated that all three sources of variance had significance values of < 0.05 , leading to the conclusion that all variables had a statistically significant effect on learning outcomes, as shown in Table 4.

Table 4. Two-Way ANOVA Results

Source	F	Sig.	Interpretation
Media	97.937	0.000	Significant effect on conceptual understanding
KKVS (Visual-Spatial Intelligence)	113.203	0.000	Significant effect on conceptual understanding
Media × Visual-Spatial Intelligence Interaction	8.853	0.004	Significant interaction between media and visual-spatial intelligence

R-Squared	0,780 (Model explains 78% of posttest score variance)
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Discussion

The findings of this study indicate that the use of Google Sites had a more significant impact on improving students' conceptual understanding of area and volume compared to the use of e-books. This result is consistent with previous studies by Salasa et al. (2023) and Mulyaningsih et al. (2023), which emphasized that Google Sites promotes interactive learning and enhances understanding through multimedia features. The presentation of content in visual formats—such as videos, interactive quizzes, and animations—helps students grasp spatial concepts more concretely, particularly in the context of area and volume measurement.

Unlike Google Sites, e-books are relatively passive due to their reliance on static text and images, which limits their capacity to support optimal visualization of three-dimensional objects. This finding reinforces Gardner's (2007) view that visual-spatial intelligence plays a critical role in geometry-based learning. The results also revealed that students with high visual-spatial intelligence achieved higher posttest scores than those with low intelligence levels, as supported by Mix et al. (2021).

Furthermore, the interaction between learning media and visual-spatial intelligence was statistically significant. Students with high visual-spatial intelligence showed the greatest improvement when using Google Sites. This suggests that the effectiveness of learning media is highly influenced by students' cognitive characteristics. On the other hand, students with lower visual-spatial intelligence did not exhibit substantial differences in outcomes between Google Sites and e-books. However, the Google Sites group still performed slightly better, indicating that the medium may help mitigate visual-spatial limitations to some extent.

Overall, these findings contribute theoretically to the growing body of literature on the effectiveness of web-based media in visual-spatial mathematics learning. They also reinforce the constructivist approach to education, where media serves as a facilitator linking new knowledge with students' concrete experiences (Khaerunnisa, 2024).

The practical implications of this study highlight the importance of considering student characteristics—such as visual-spatial intelligence—when selecting instructional media. Teachers are encouraged to use platforms like Google Sites for spatial mathematics content due to their ability to support visual and interactive exploration of concepts. This study also opens up opportunities for the development of adaptive learning media tailored to students' intelligence profiles in order to enhance learning effectiveness more holistically.

Conclusion

This study concludes that the use of digital learning media significantly enhances elementary students' conceptual understanding of area and volume, with Google Sites proving more effective than e-books. The interactive features of Google Sites such as videos, animations, 3D images, and visual quizzes successfully help students visualize abstract geometric concepts, thereby deepening comprehension. Moreover, students' levels of visual-spatial intelligence play a crucial role in learning outcomes; those with higher visual-spatial abilities achieve greater understanding and application of measurement concepts. The interaction between media type and visual-spatial intelligence further indicates that the

effectiveness of learning media depends on students' cognitive characteristics, emphasizing the need for media selection that aligns with learners' diverse abilities.

In essence, this research highlights that integrating interactive digital platforms like Google Sites into mathematics instruction not only supports conceptual learning but also advances adaptive and inclusive educational practices. It reinforces constructivist and multiple intelligences theories, demonstrating that learning becomes more meaningful when media design corresponds to students' cognitive strengths. Thus, digital media integration in education represents not just technological innovation but a strategic effort to create more effective, engaging, and equitable learning experiences.

Recommendation

Based on the conclusions above, the researcher proposes several recommendations: 1) Development of Visual-Interactive Learning Theory. The findings of this study reinforce the theory that visual and interactive learning media are highly effective in facilitating the understanding of abstract mathematical concepts such as area and volume. This highlights the vital role of technology in supporting constructivist learning theory, particularly in the context of geometry instruction at the elementary school level. 2) Contribution to the Theory of Multiple Intelligences. This research supports the idea that visual-spatial intelligence is a critical factor to be considered in the design of learning experiences. Therefore, learning media should be tailored to align with students' dominant intelligence types in order to optimize the knowledge construction process. 3) Implications for Instructional Design. The results of this study serve as a reference for developing digital-based learning models that accommodate students' individual differences. Thus, media such as Google Sites should not merely be seen as supplementary tools, but as integral components of instructional strategies that are responsive to learners' diverse cognitive characteristics. Recommendation describe things that will be done related to the next idea of the research. Barriers or problems that can influence the results of the research are also presented in this section.

Acknowledgment

The researcher would like to express sincere appreciation to the Graduate School of Universitas PGRI Adi Buana Surabaya, particularly the Educational Technology Program, for the academic support and guidance throughout the completion of this research.

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