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THE EFFICACY OF INTERACTIVE APPLICATION BASED MEDIA IN ENHANCING SPATIAL GEOMETRY: A STUDY AT ONE OF THE ELEMENTARY SCHOOL IN BANDUNG

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Abstract: Mathematics instruction regarding spatial geometry in elementary education frequently encounters pedagogical hurdles due to the abstract nature of the concepts, the inadequacy of conventional instructional tools, and suboptimal student engagement. This study aims to develop and evaluate the effectiveness of an interactive, application-based learning tool designed to bridge the gap between abstract geometric concepts and student comprehension. Adopting a DesignBased Research (DBR) framework, the study focused on the iterative development of an interactive media product. The research subjects were 29 fifth-grade students at one of the elementary school in Bandung. Data were triangulated through pre-test and post-test assessments, systematic observation of student activities, and user experience (UX) questionnaires. The media was constructed using Smart Apps Creator and Canva for high-fidelity visual design. The findings demonstrate that the developed media significantly improved student learning outcomes, with an N-gain score falling within the "Moderate" effectiveness category. Furthermore, the media elicited high positive responses regarding student motivation, aesthetic visual design, and interface usability. Reflective analysis suggests that while effective, future iterations should prioritize enhanced audio synchronization, intuitive navigation, and more robust interactive features to maximize pedagogical impact. Overall, this application-based medium serves as a practical and effective alternative for teaching spatial geometry in primary education.

Keywords: Interactive Application-Based Media; Elementary Mathematics; Spatial Geometry; Design-Based Research; Elementary School Bandung

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INTRODUCTION

Mathematics is an important subject in elementary school as it plays a significant role in developing students' logical thinking, problem-solving skills, mathematical communication, and spatial reasoning abilities. Through mathematics learning, individuals are equipped with abstraction skills, problem analysis abilities, and strong logical reasoning (Siswanto & Meiliasari, 2024). One of the essential topics in elementary mathematics is solid geometry. This topic requires students to understand threedimensional shapes along with their elements,

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such as faces, edges, vertices, volume, and surface area. Understanding solid geometry concepts is highly important because it is closely related to students' visualization and spatial reasoning abilities in interpreting objects in their surrounding environment.

However, solid geometry is often considered difficult by elementary school students because the concepts are abstract and require the ability to mentally visualize three-dimensional objects. As a result, students frequently struggle to understand the material when it is presented only through two-dimensional images in textbooks. This difficulty indicates that mathematics learning, particularly solid geometry, should be delivered in a more concrete, contextual, and interactive manner to help students understand concepts more effectively. Nevertheless, classroom practices still tend to apply conventional teacher-centered approaches through lectures and the use of static learning media. Such approaches are less effective in providing visual and interactive learning experiences, causing students to become less active and less engaged in the learning process. When only some students actively participate while others remain passive, the effectiveness of learning outcomes tends to decrease (Kamarudin in Paramita et al., 2023). In line with this, several studies have shown that mathematics learning, especially in geometry, is still largely dominated by conventional teacher-centered approaches through lectures and the use of static instructional media (Aprilian in Wariningsih, et al., 2026). This condition prevents students' visual learning needs from being optimally facilitated, even though visualization skills play an important role in understanding solid geometry concepts.

These problems have contributed to students' suboptimal learning outcomes, particularly in topics requiring high visualization skills such as solid geometry. Research by Sarama and Clements (2009) in Early Childhood Mathematics Education Research revealed that many students experience difficulties in understanding geometric concepts due to the lack of visual and manipulative learning experiences. These findings emphasize that students need learning experiences that allow them to observe, manipulate, and explore geometric objects more concretely so that abstract concepts can be understood more easily.

The development of digital technology provides new opportunities to create more interactive and meaningful mathematics learning. Interactive application-based media enable students to view, rotate, enlarge, and manipulate three-dimensional objects directly, making abstract concepts more concrete. The use of interactive digital media can also increase students' engagement in the learning process by providing visual, attractive, and participatory learning experiences. This indicates that mathematics learning in elementary schools should be presented contextually by utilizing media and technology so that students can visualize mathematical concepts, procedures, and principles more concretely (Arbain & Sirad, 2023). The use of digital media not only helps students visualize concepts but also provides direct experiences in manipulating three-dimensional objects (Amalia, et al., 2026). This is highly beneficial in learning three-dimensional geometry because students can more easily

understand the shapes and properties of solid figures, which are often difficult to learn solely through two-dimensional textbook illustrations.

Based on these problems, learning innovations are needed to provide students with more interactive, visual, and meaningful learning experiences. One alternative that can be implemented is the use of interactive application-based learning media. This media is designed to help students visualize solid geometry concepts more concretely through engaging visual displays, animations, and interactive features that enable students to actively participate in the learning process.

Based on the explanation above, this study aims to develop and examine the effectiveness of interactive application-based learning media in improving elementary school students' understanding of solid geometry concepts. Specifically, this study aims to: (1) produce valid and feasible learning media for mathematics instruction, (2) determine the improvement in students' learning outcomes after using interactive media, and (3) analyze students' activity levels and responses toward the use of the media in solid geometry learning. Therefore, the developed media is expected to become an innovative solution for overcoming students' difficulties in understanding abstract geometry concepts.

METHOD

This study employed a Design-Based Research (DBR) approach. This approach was selected because DBR is a systematic, yet flexible research method aimed at improving educational practices through iterative processes of analysis, design, development, implementation, and reflection. In addition, DBR not only focuses on the development of instructional products but also generates theoretical insights that contribute to the continuous improvement of teaching practices.

The stages of the DBR approach, as proposed by McKenney and Reeves (Schmalenbach & Ashouri, 2025), consist of:

1. Analysis and exploration, in which the problem is identified and analyzed through literature review and collaboration with practitioners.
2. Design and construction, a "deliberative–generative cycle" in which a tentative solution is developed by considering existing knowledge and relevant conceptual relationships.
3. Evaluation and reflection, where the solution is implemented, its quality is examined, and through reflection, the results of research and development are analyzed and integrated. This phase may lead to ideas for redesigning the developed intervention

The subjects of this study were elementary school students learning solid geometry. Data were collected through learning outcome tests, student activity observation sheets, and student response questionnaires. Learning outcomes were analyzed using the N-gain formula to determine the improvement in students' abilities after using the interactive learning media.

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Meanwhile, student activity and response data were analyzed using descriptive quantitative methods.

The expert validation instrument was assessed using a Likert scale ranging from 1 to 4, where a score of 1 indicates that no indicators are present, 2 indicates that only one indicator is present, 3 indicates that two indicators are present, and 4 indicates that all indicators are present. The obtained data were then calculated and interpreted based on the following feasibility criteria

Table 1. Feasibility Interpretation Criteria

Percentage (%)	Description
$80 \leq F \leq 100$	Very valid, can be used without revision.
$60 \leq F < 80$	Valid, can be used but needs minor revision.
$40 \leq F < 60$	Quite valid, can be used but needs moderate revision.
$20 \leq F < 40$	Less valid, recommended not to be used before major revision.
$F < 20$	Very invalid, cannot be used.

The student questionnaire instrument was measured using a Likert-type attitude scale consisting of Strongly Disagree (SD), Disagree (D), Agree (A), and Strongly Agree (SA). The results were interpreted based on the following criteria.

Table 2. Student Questionnaire Assessment Criteria

Percentage (%)	Criteria
QA<20	Very Poor (VP)
20 ≤ QA < 40	Poor (P)
40 ≤ QA < 50	Sufficient (S)
50 ≤ QA < 80	Good (G)
80 ≤ QA ≤ 100	Very Good (VB)

Assessment of the student activity observation instrument was carried out using a Likert scale with a range of 1-4 which includes a score of 1 = 25% of students are active according to the observation indicator, a score of 2 = 50% of students are active according to the observation indicator, a score of 3 = 75% of students are active according to the observation indicator, and a score of 4 = 100% of students are active according to the observation indicator. After the data has been calculated, the results are interpreted based on the assessment criteria for the results of student activity observations as follows.

Table 3. Assessment Criteria for Student Activity Observation Results

Percentage (%)	Criteria
QA<20	Very Poor (VP)
20 ≤ QA < 40	Poor (P)
40 ≤ QA < 50	Sufficient (S)
50 ≤ QA < 80	Good (G)
80 ≤ QA ≤ 100	Very Good (VB)

RESULT AND DISCUSSION

In this study, to determine the extent to which students' analytical skills improved after receiving a learning treatment, Normalized Gain (N-Gain) was used. The use of NGain is considered more appropriate because it not only looks at the difference between initial and final scores but also considers the potential for maximum improvement achieved by students. N-Gain can provide a more objective picture of the effectiveness of a treatment in improving learning outcomes. The results of the N-Gain calculations were then analyzed descriptively to determine the increasing trends across the entire study sample. A summary of the descriptive statistical analysis of the N-Gain scores and their percentages is presented in the following table.

Table 4. N-gain Effectiveness Test Results

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_Score	29	.43	.67	.58	.057
Ngain_Percent	29	42.86	66.67	57.60	5.65

Based on the table, it is known that the number of data analyzed was 29 students. The N-Gain score ranged from 0.43 to 0.67 with an average of 0.58 and a standard deviation of 0.057. Meanwhile, the N-Gain percentage ranged from 42.86% to 66.67% with an average of 57.60% and a standard deviation of 5.65. The average N-Gain within this range indicates that the increase in student learning outcomes was in the moderate category. This indicates that the learning treatment provided was quite effective in improving student abilities, although there were still variations in improvement between individuals as indicated by the standard deviation value.

In addition to reviewing learning outcomes through N-Gain analysis, the effectiveness of learning in this study was also strengthened by observational data on student activities during the learning process. While N-Gain provides a quantitative overview of cognitive improvement, the observational results complement these findings by demonstrating direct

student involvement in the affective and psychomotor domains. The results of observations of student activities were then summarized to determine their level of engagement in various aspects of the learning process. This summary covers verbal, motor, mental, and emotional activities, presented as percentages and assessment categories. The complete results of the observation summary are presented in the following table.

Table 5. Recapitulation of Observation Results

Aspect	Percentage	Description
Oral Activities	87,5%	Very good
Motor Activities	75%	Good
Mental Activities	75%	Good
Emotional Activities	87,5%	Very good
Average	**81,25%**	**Very good**

Based on the observation result recapitulation table, it can be seen that the students' activities during the learning process showed very good results with an average percentage of 81.25%. In detail, the oral activities and emotional activities obtained the highest percentage of 87.5% with a very good category, which indicates that the students were active in communicating and had positive emotional involvement during the learning process. Meanwhile, the motor activities and mental activities each obtained a percentage of 75% with a good category, which indicates that the students were quite involved in both physical activities and thinking processes during the learning process. Overall, these results indicate that the learning implementation was able to encourage students' activeness in various aspects, thus supporting the improvement of learning outcomes as shown through the N-Gain analysis.

Furthermore, to determine student responses to the implemented learning, a student response questionnaire was distributed covering several aspects, namely ease of use of the application, interest and motivation, design and visual appearance, and understanding and accessibility of the material. Student responses are an important indicator because they reflect perceptions, interests, and direct learning experiences. The summary of student responses is presented as percentages and assessment categories in the following table.

Table 6. Recapitulation of Student Questionnaire Sheets

Aspects	Percentage	Description
Ease of Use of Application	84,3%	Very Good

Interest and Motivation	85,6%	Very good
Design and Visual Appearance	85,9%	Very good
Material Understanding and Accessibility	84,5%	Very good
Average	85,1%	Very good

Based on the recapitulation table of student responses, it was found that all aspects were categorized as very good with an average percentage of 85.1%. In detail, the interest and motivation aspects obtained a percentage of 85.6%, and the design and visual appearance of 85.9%, which indicates that students feel interested and motivated and consider the appearance of the application used to be attractive. In addition, the aspect of ease of use of the application obtained a percentage of 84.3%, and the understanding and accessibility of the material was 84.5%, which indicates that the application is easy to use and helps students in understanding the learning material. Overall, these results indicate that the learning implemented received a very positive response from students, thus further strengthening the finding that the learning was effective both in terms of learning outcomes, activeness, and student learning experiences.

DISCUSSION

In this study demonstrate that interactive application-based learning media developed using Smart Apps Creator and Canva is effective in improving fifth-grade students' learning outcomes on solid geometry material, as evidenced by an average NGain score of 0.58, which falls within the "Moderate" category. This finding is consistent with previous research showing that technology integrated instruction produces measurable learning gains in elementary mathematics. A study by Outhwaite, et al. (2019) published in Early Childhood Education Journal found that students using interactive math apps made significant learning gains compared to those receiving standard instruction only, with the greatest impacts observed among students with lower baseline knowledge levels.

The use of Smart Apps Creator (SAC) as the primary development platform aligns with a growing body of research affirming the pedagogical value of Android based interactive media. Rukoyah and Bektiningsih (2024), in a study published in Jurnal Penelitian Pendidikan IPA, developed interactive learning media using Smart Apps Creator for elementary school students and found it to be effective in enhancing science learning outcomes. Furthermore, Study Dengkidala, et al. (2026) published in the Journal of Innovation and Research in Primary Education on SAC based digital media for elementary science achievement found that Smart Apps Creator based digital media significantly enhances learning outcomes through multimodal content delivery and interactive engagement, supporting technology integration as an equity enhancing pedagogical strategy. These findings further validate the instructional design decisions made in the present study,

particularly the choice of combining SAC's interactive architecture with Canva's high fidelity visual design capabilities.

The observational data, which obtained an overall average score of 81.25% categorized as "Very Good," further confirms that the developed media was effective not only in improving cognitive outcomes but also in supporting other aspects of learning. The high scores in Oral Activities (87.5%) and Emotional Activities (87.5%) were particularly notable findings. These results are in line with studies Pitchford & Outhwaite (2019) showing that interactive application-based learning can provide positive effects on students' affective and attentional aspects. Research published in PMC reported that teachers in several countries implementing interactive math applications observed improved student concentration, as children appeared more focused after using the application. This indicates that engagement through interactive media can positively influence students' attention and emotional conditions. The high score in emotional activities found in this study was likely influenced by the application's attractive visual design and interactive features, which was also supported by the questionnaire results.

The results of the student response questionnaire, which obtained an average score of 85.1% and was categorized as "Very Good" across all four aspects, indicate that students experienced a highly positive learning process. These findings are consistent with the study conducted by Rahmah, et al. (2025), which specifically examined the effect of Augmented Reality media on elementary students' learning outcomes in solid geometry. The study found that students who learned using digital visual media achieved higher learning outcomes compared to those who did not use such media. This suggests that interactive visual media can serve as an effective alternative to help students understand three-dimensional geometry concepts more concretely. These findings are highly relevant to the present study, considering that solid geometry inherently requires strong spatial visualization skills, which can be significantly enhanced through interactive digital representations.

CONCLUSION

This study demonstrates that the development of interactive application-based learning media contributes significantly to creating a more concrete, engaging, and student-centered mathematics learning environment, particularly in teaching spatial geometry at the elementary school level. Through the Design-Based Research (DBR) approach, the developed media functioned not only as a visual instructional tool but also as a medium that facilitated active student engagement, thereby supporting the development of spatial reasoning and deeper conceptual understanding. The findings reinforce the importance of integrating digital technology into mathematics instruction to bridge the gap between abstract concepts and students' real learning experiences. Furthermore, this study extends current knowledge regarding the use of application-based interactive media as an innovative alternative for supporting more effective, adaptive, and technology-oriented learning

practices that align with the needs of today's digital generation. The developed media also has the potential to be implemented in other mathematics topics and across different educational levels with appropriate modifications. Future research is recommended to incorporate more advanced interactive features, improve audio synchronization and navigation systems, and examine the effectiveness of the media on broader and more diverse samples in order to gain a more comprehensive understanding of the impact of interactive digital media on mathematics learning quality.

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