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Quality of Geometry Cards Based on Augmented Reality to Improve Critical Thinking Skills in Elementary Students

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Abstract: This study aims to determine the validity and practicality of the mathematics building card learning media using Augmented Reality technology to improve critical thinking skills. This study uses the design and development stages. The design stage aims to design a prototype of the mathematics building card using Augmented Reality technology. In contrast, the development stage seeks to test the validity and practicality of the mathematics building card using Augmented Reality technology. The subjects involved in the study were seven validators in the expert validation activity and 11 people in the product practicality activity. Data analysis used V Aiken for expert validation, while practicality used the percentage of practicality. The expert validation results showed that the V Aiken calculation results were more than 0.76 for each item. The practicality results obtained a percentage for each statement item of more than 77.27. Based on these results, it can be concluded that the mathematics building card learning media product using Augmented Reality technology can be categorized as valid and practical. The results of this study imply that research products need to be further researched, such as testing the effectiveness of the resulting product.

Keywords: Augmented Reality; Geometry card; Media of learning; critical thinking skills.

Kualitas Kartu Geometri Berbasis Augmented Reality Untuk Meningkatkan Kemampuan Berpikir Kritis Siswa Sekolah Dasar

Abstrak: Penelitian ini bertujuan untuk mengetahui tingkat validitas dan kepraktisan media pembelajaran kartu bangun Matematika menggunakan teknologi Augmented Reality untuk meningkatkan kemampuan berpikir kritis. penelitian ini menggunakan tahapan desain dan develop. Tahapan desain bertujuan untuk mendesain prototipe kartu bangun Matematika menggunakan teknologi Augmented Reality, sedangkan tahap develop bertujuan untuk menguji validitas dan kepraktisan kartu bangun Matematika menggunakan teknologi Augmented Reality. Subyek yang terlibat pada penelitian adalah 7 orang validator pada kegiatan validasi ahli, dan 11 orang pada kegiatan kepraktisan produk. Analisis data yang digunakan menggunakan V aiken untuk validasi ahli, sedangkan kepraktisan menggunakan persentase kepraktisan. Hasil validasi ahli diperoleh bahwa hasil perhitungan V aiken yang diperoleh lebih dari 0,76 untuk setiap item, sedangkan hasil kepraktisan diperoleh persentase untuk setiap item pernyataan lebih dari 77,27. Berdasarkan hasil ini dapat disimpulkan bahwa produk media pembelajaran kartu bangun Matematika menggunakan teknologi Augmented Reality dapat dikategorikan valid dan praktis. Hasil penelitian ini menyiratkan bahwa produk penelitian perlu dilakukan penelitian lanjutan seperti menguji keefektifitasan produk yang dihasilkan.

Kata Kunci: Augmented Reality; Kartu geometri; Media pembelajaran; Kemampuan berpikir kritis

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INTRODUCTION

Critical thinking skills are high-level thinking skills that help analyze and consider solutions obtained in solving problems (Benyamin et al., 2021; Ibrahim et al., 2021; Martyanti & Suhartini, 2018). This ability is a soft skill, reflective thinking, the ability to have logical and systematic reasons in making decisions (Murni et al., 2022; Nuryanti et al., 2018; Sulistyowati et al., 2022; Wulansari et al., 2019). Critical thinking can be thought of as the ability to reason and absorb as much information as possible about a problem, which includes methods of examination or reasoning to make a decision or take action (Caesario & Ardiansyah, 2023; Rositawati, 2019; Shanti et al., 2017). All students must have critical thinking skills because this ability can evaluate and analyze every new information received (Astuti et al., 2023; Firdaus & Wilujeng, 2018; K. E. Lestari, 2014; Prasetiyo & Ma'arif, 2021).

However, the condition of critical thinking skills in the field still shows results that are less than encouraging or are still low (Agnafia, 2019; Nuryanti et al., 2018; Priyadi et al., 2018). One of the reasons is that the learning process carried out by teachers is more mechanical. Namely, teachers provide examples of questions before giving students tests so that they experience difficulties if given questions in a different format (Ariani, 2020; Ibrahim et al., 2021). The results of the 2022 PISA survey show that scores have decreased compared to the previous year (Prihantono, 2023; Santi et al., 2022), Although the PISA questions given do not directly measure critical thinking skills. Because PISA questions do not measure memorization of facts, students are required to utilize mathematical skills such as critical thinking, creativity, and problem-solving in the real world (Diana & Saputri, 2021; A. C. Lestari & Annizar, 2020; Rosmalinda et al., 2021). In addition, low critical thinking skills can be seen in students who have difficulty working on questions correctly, cannot create mathematical models, and cannot solve questions correctly (Benyamin et al., 2021). The results of previous research on high school students in Pelalawan Regency showed that critical thinking skills were still low. The low critical thinking skills are caused by students being only able to complete calculations but cannot connect concepts with actual conditions (Priyadi et al., 2018). Likewise, students of the state Islamic Senior High School in Magetan and Junior high School students in Klaten showed low critical thinking skills (Nuryanti et al., 2018; Susilowati et al., 2017). Even though this ability is not innate, this skill can be trained and developed through learning processes and assessments (Harianja, 2020; Rahmaniah et al., 2023).

There have been many studies that focus on improving critical thinking skills. Such as guided inquiry learning, discovery learning, flipped-Classroom, problem-based learning, advocacy learning, STEM and project-based learning to enhance critical thinking skills (Amijaya et al., 2018; Ibrahim et al., 2021; Insyasiska et al., 2017; Maolidah et al., 2017; Nurrohmi et al., 2017; Priatna et al., 2020; Satwika et al., 2018). They stated that the learning model used empirically can improve students' critical thinking skills. In addition to the learning model, theoretically and empirically learning media can be used to enhance critical thinking skills (Aprilia, 2021; Asani, 2023; D. Ashari, 2023; Aziza et al., 2023; Hendi et al., 2020; Hidayatunnajah, 2021; Jannah & Atmojo, 2022; Sulistyowati et al., 2022). The study results stated that the media used were videos, worksheets, Augmented Reality (AR), spatial shape

cards, and question cards, which can improve students' critical thinking skills. These results align with the meaning of media as a learning aid and the function of learning media to provide learning stimuli, activate student responses, and provide feedback (Ningrum et al., 2023; Utami et al., 2022; S. A. Widodo, 2018; S. A. Widodo et al., 2019).

METHOD

Following the objectives of this study, namely to determine the validity and practicality of the mathematics building card learning media using Augmented Reality technology to improve critical thinking skills, this study uses two stages. The two stages are design and develop (see Figure 1). These two stages are part of the development research on the 4D model: define, design, develop, and disseminate (Thiagarajan et al., 1974).

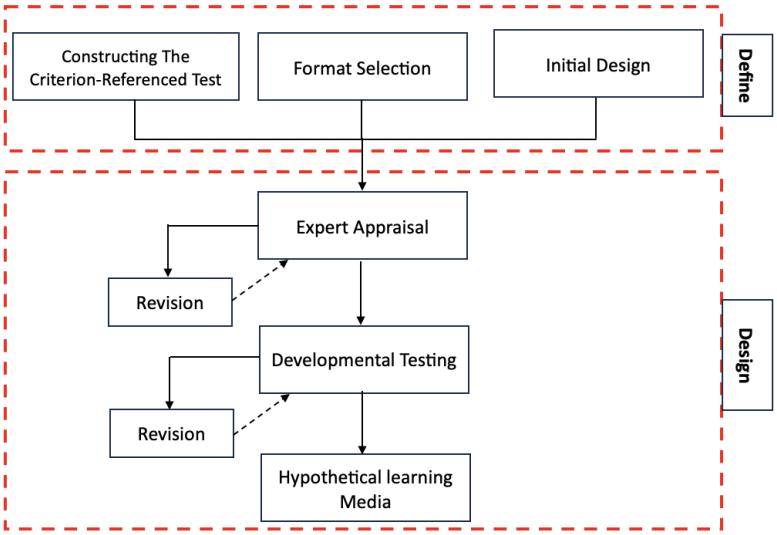

Figure 1. Research stage

At the design stage, the aim is to design or create a sketch of learning media in the form of Mathematical Space Cards based on Augmented Reality. At this stage, it is done by constructing the criterion-referenced test, format selection, and initial design (Thiagarajan et al., 1974). At the construction criterion-referenced test stage, the instrument needed to evaluate the learning media product is prepared, such as product validation sheets, student response sheets, and teacher response sheets. The format selection stage is the stage of selecting the presentation form according to the media being developed. In this study, the geometry card media developed was in the form of AR. The initial design stage is designing the initial draft of the learning media product developed before the feasibility and validation tests are carried out by expert validators in the relevant fields. The data analysis technique used at the design stage describes the design process of the mathematical space card based on augmented reality and the instruments needed in this study.

The main objective at the development stage is to obtain fit and good learning media. Fit and good learning media means that the media is ready to be used for large-scale trials. Expert appraisal and developmental testing are conducted to get a fit and good product

(Thiagarajan et al., 1974). The specialist appraisal step aims to assess the Mathematical Space Card based on Augmented Reality that has been developed. The instrument used in the expert appraisal is a validation sheet. This instrument is created from 3 aspects, namely the product design aspect, the material aspect, and the language and communication aspect. The data analysis technique used in expert validation uses content validity. This validity provides evidence of the extent to which the elements of the assessment instrument are relevant and represent the targeted construct for a particular assessment purpose (Almanasreh et al., 2019). The content validity in this study uses the Aiken method in its statistical calculations (Aiken, 1980, 1999). A product is said to have good validity if the V Aiken value is obtained at least 0.76 for a significance level of 5%. This index value is obtained from the V Aiken table with an N size of 7. In addition to being analyzed using V Aiken to see the validity of the content and feasibility of the developed learning media product, the assessment results are used to revise the product. Product revisions are made based on comments, suggestions, and assessments of expert validators.

Developmental testing is a product design trial activity on a small-scale target subject (Thiagarajan et al., 1974). During this trial, response data, reactions or comments from target users of the research product are sought. Therefore, in this study, developmental testing aims to test the practicality of the Mathematical Space Card based on Augmented Reality that has been developed. This stage involved eight students and three teachers who were taken by purposive sampling. The data analysis technique on product practicality uses the percentage obtained from the comparison between the weight of the score obtained and the maximum score expected. Furthermore, a product can be considered practical if the practicality percentage is between 50 – 75, while it is very practical if it is between 76 – 100 (Masruhah et al., 2022).

RESULT AND DISCUSSION

Result

The design stage starts with sketching a geometric card-shaped media product applied to the augmented reality platform. The activities used to create this product are (1) determining the structure, sequence and scope of the subject matter and (2) designing the concept of the number card product that is applied to the augmented reality platform.

The teaching media developed following the learning objectives in the geometry elements for the end of phase C, such as students can construct and analyze geometric shapes and recognize spatial visualization. In this learning objective, the material given is the properties of shapes, nets, area and volume of geometric shapes (cubes, blocks, triangular prisms, rectangular pyramids, cones, cylinders, and spheres). For each geometric shape, there are five material menus in the mathematical geometric shape card media, namely (1) geometric shape images, (2) geometric shape nets, (3) geometric shape properties, (4) formulas for determining the area and volume of geometric shapes, and (5) examples of

questions related to everyday life. This is what researchers do to determine the learning material's structure, sequence and scope.

Researchers used the Assembly Edu and Microsoft Word applications to design the concept of a number card product applied to the augmented reality platform. Assemblr Edu is an Augmented Reality platform explicitly used for educational purposes with 3D and Augmented Reality technology. This platform facilitates the learning process by creating interactive learning media. Microsoft Word is a word-processing application for creating, editing, and formatting data in text or writing. Microsoft Word is used to design the contents of the mathematical geometric shape card according to the desired format, such as text, giving attractive colours, text boxes, image illustrations and also evaluation questions.

Figure 2. Pre-design of Learning Media Product

An example of the initial design of a mathematical spatial media card product can be seen in Figure 2. This figure presents the initial design of the development product contained in the mathematical spatial media card: spatial images, spatial net images, spatial properties, formulas for the area and volume of spatial shapes, and examples of spatial practice questions. After the product design has been completed, a barcode is obtained using the Assemblr Edu application, as shown in Figure 3.

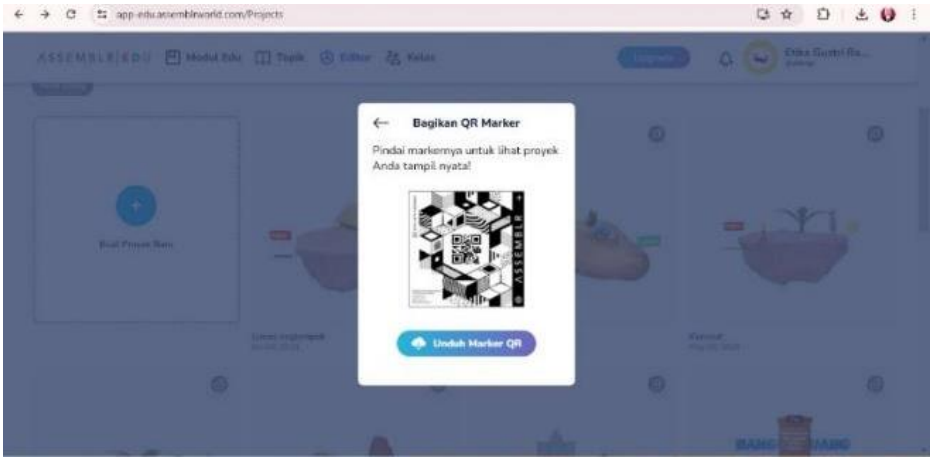

Figure 3. Barcode code that has been created

After the barcode is obtained, the barcode image is downloaded, printed using photo paper, and attached to the cardboard that has been provided. An example of the printed barcode can be seen in Figure 4.

Figure 4. The finished Mathematics Cards

The development stage is the stage to produce augmented reality-based number card products. Two things that must be done at this stage are validation and developmental testing. Validation testing is a validation activity done by experts. This validation aims to provide advice and assess the feasibility of a product design. Furthermore, improvements are made from these suggestions and assessments before being used for developmental testing activities. The developmental testing stage is a small-scale trial stage that aims to find out whether there are still errors in the guided discovery-based module and ask for suggestions for improvement based on the obstacles found by students.

In the validation testing activity, the experts involved were five lecturers with a doctoral background in Mathematics Education. They assessed the augmented reality-based number card product by focusing on mathematical content. In addition to involving five lecturers in Mathematics Education, this product was also validated by two practitioners with a background in elementary school teaching and a minimum of a master's degree. A summary of the validation results can be seen in Table 2.

Table 2. Summary of Content Validity results using V Aiken

Aspect	Statement of Items	V Aiken
Design	Easy-to-use product	0.905
	Easy to operate product for learning	0.952
	The product can be used on smartphones	0.952
	Suitability of illustration design	0.810
	Product display design	0.905
	Product animation design	0.857
	Attractive space building card media animation design	0.952
content	Personal skills	0.857
	Social skill	0.952
	Suitability of material content	0.857
	Quality of content	0.905
	Suitability to student development level	0.952
	Consistency of geometric images	0.952
	Questions or exercises on geometric shape cards	0.857
language and	Conformity with Indonesian language rules	0.857
communication	Communicative with other students	0.905
	Consistency of storyline	0.905
	Communication with the author	0.810

Based on Table V Aiken for N (number of raters/validators) of 7 people with four answer choices, 0.76 was obtained for a significance level of 5%. By looking at the results of the V Aiken calculation, which can be seen in Table 2, it is concluded that the Mathematical Space Card product based on Augmented Reality is valid based on aspects of design, material, language and communication. This is because the results of the V Aiken calculation obtained are more than 0.76.

Developmental testing was conducted to determine the responses of students and teachers to the use of the developed product. The research product was tested on eight students and three elementary school teachers who were selected purposively to determine the students' responses. The student response questionnaire consisted of 7 items, namely (1) is the teaching media of the Spatial Card through augmented reality technology easy to use for learning, (2) can the teaching media of the Spatial Card through augmented reality technology be used as a learning resource?, (3) is the teaching media of the Spatial Card

through augmented reality technology easy to access?, (4) is the scope of the teaching media material of the Spatial Card through augmented reality technology complete?, (5) are the images contained in the media of the Spatial Card through augmented reality technology interesting?, (6) is the teaching media of the Spatial Card through augmented reality technology helpful in learning mathematics?, and (7) is the teaching media of the Spatial Card through augmented reality technology easy to use and easy to store? The summary of the responses of students and teachers can be seen in Table 3.

Table 3. Summary of student and teacher response results

No	Statement	Percentage
1	The use of teaching media in the form of Spatial Building Cards through augmented reality technology in learning is easy to use	81.82
2	Teaching media for spatial building cards using augmented reality technology can be a learning resource.	88.64
3	Accessing the Spatial Building Card teaching media through augmented reality technology is easy to access	81.82
4	The scope of teaching media material for Spatial Building Cards through augmented reality technology is complete	77.27
5	The media image of the Space Building Card through augmented reality technology is interesting	90.91
6	There are many benefits to using the Space Building Card teaching media through augmented reality technology.	84.09
7	The advantages of the augmented reality technology-based spatial building card teaching media are that it is easy to use and store.	79.55
	average	83.44

Based on Table 3, it is obtained that the percentage of practicality for each statement item is more than 77.27. In addition, an average practicality of 83.44% was also obtained with a very practical category.

Discussion

Learning media is used in student learning to stimulate learning (Hakim et al., 2019; S. A. Widodo, 2018)(Nasution, 2015). Learning media functions to help facilitate the teaching and learning process. According to its definition, learning media is a communication tool for exchanging information between learning sources and recipients of information, in this case, students (N. Ashari et al., 2020; Salomon, 2012). Learning media used in the teaching and learning process can psychologically influence students. For this reason, the use of learning media is expected to be adjusted to the characteristics of students and the environment around students, especially in mathematical learning (Lai & Hong, 2015; Suharini et al., 2020).

This is in line with the results of previous research, which stated that the use of learning media that is adapted to the characteristics of children's cognitive development could improve children's mental abilities (S. A. Widodo, 2018; S. A. Widodo et al., 2018), reduce the level of abstraction of mathematics for students (Hakim et al., 2019), and increase motivation to learn mathematics (Puspitarini & Hanif, 2019).

Learning media should follow technological developments so that the media used for learning becomes more modern, following the times, and indirectly can motivate students to learn mathematics because the content and context in mathematics are considered not outdated for students. This aligns with previous research stating that combining spatial cards with augmented reality positively affects students' conceptual understanding abilities and learning motivation (Fitria et al., 2019; Kelen et al., 2024).

Augmented Reality is a technology that combines 2D and 3D visual forms into a natural environment and then projects the virtual form in real time (Ardhianto et al., 2012; Madani et al., 2018; Ramadhan et al., 2021; Suryawinata, 2010). Augmented reality technology displays objects that help users generate new perceptions, allowing students to interact with the natural environment and allowing users to move and observe the displayed models from various sides (Asmah & Purwaningsih, 2023; Faghrudin & Hartono, 2022; Suryawinata, 2010; S. Widodo et al., 2019). Learning experiences like this can make the learning process more embedded in their memory because it can make it easier for them to learn abstract mathematical material.

The results of this study indicate that the quality of the learning media product in the form of Augmented Reality-Based Geometry Cards is very good. This can be shown from the assessment results by expert validators and the results of the content validity analysis using the V Aiken formula, which obtained more than 0.76. In addition, the results of limited-scale trials at the developmental testing stage showed that the average practicality of 83.44% was also obtained in a very practical category. Although this study has not been widely tested to see the effects of augmented reality learning media on students' critical thinking skills, in theory and implementation in the field that has been done previously, augmented reality learning media can improve students' cognitive abilities. Such as augmented reality research on three-dimensional material or spatial structures (Rafiko & Sunardi, 2022; Suwito et al., 2023). Ihsan et al. in 2017 used augmented reality to introduce mathematical arithmetic operations to kindergarten and early childhood education students (Ihsan et al., 2017), Augmented reality media to improve critical thinking skills (D. Ashari, 2023; Hidayatunnajah, 2021), the influence of augmented reality on conceptual understanding ability (Kelen et al., 2024).

CONCLUSION AND RECOMMENDATION

From the results of the research and discussion, it can be concluded that the quality of the learning media product in the form of Augmented Reality-Based Geometry Cards to Improve Critical Thinking Skills in Elementary School Students is in the very good category. This can be shown from the assessment results carried out by seven expert validators. Content

validity analysis was carried out using the Aiken V formula, and more than 0.76 were obtained. In addition, the results of the limited scale trial at the developmental testing stage showed that the average practicality of 83.44% was also obtained with a very practical category.

Based on the results of this study, it is suggested that the Augmented Reality-Based Geometry Card media needs to be tested on a large scale (dissemination stage) to see whether this learning media product can improve critical thinking skills in Elementary School Students.

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