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Flashcard Media Based on Augmented Reality in Building Spatial Materials to Improve Cognitive Learning Outcomes of Fifth- Grade Students in Elementary School

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ABSTRAK

Kurangnya penggunaan media dalam proses pembelajaran matematika kemudian berdampak pada rendahnya kemampuan kognitif siswa, sehingga untuk mengatasi permasalahan tersebut siswa membutuhkan media yang dapat membantu proses belarnya. Adapun tujuan dari penelitian ini yakni untuk menghasilkan produk media flashcard berbasis augmented reality sebagai media yang valid, praktis dan efektif untuk meningkatkan hasil belajar kognitif siswa. Penelitian ini tergolong kedalam jenis penelitian pengembangan yang dikembangkan menggunakan model ADDIE dengan tahapan analisis, desain, pengembangan, implementasi, dan evaluasi. Subjek yang terlibat dalam penelitian ini yakni validator, guru, serta siswa kelas V SD. Pengumpulan data dilakukan dengan menggunakan metode observasi, wawancara, kuesioner, dan tes. Instrument pengumpulan data menggunakan angket dan soal tes. Teknik analisis data menggunakana analisis deskriptif kualitatif, kuantitatif, dan uji-t. Hasil analisis menunjukan validasi ahli materi memperoleh persentase 79,2% masuk dalam kriteria valid. Kriteria kedua yaitu praktis melalui angket guru dan siswa uji coba kelompok kecil memperoleh persentase 88,7% masuk dalam kriteria sangat praktis dan angket siswa memperoleh persentase 89,5% masuk dalam kriteria sangat praktis. Angket guru dan siswa pada saat uji coba kelompok besar untuk guru memperoleh persentase 91,2 % masuk dalam kriteria sangat praktis dan untuk siswa memperoleh persentase 88,3 % masuk dalam kriteria sangat praktis. Kriteria yang ketiga yaitu efektif. Berdasarkan hasil tersebut maka dapat disimpulkan bahwa media flashcard berbasis augmented reality secara signifikan dapat meningkatkan kemampuan kognitif siswa.

ABSTRACT

The lack of use of media in the process of learning mathematics then has an impact on the low cognitive ability of students, so to overcome these problems, students need media that can help the learning process. The purpose of this study is to produce flashcard media products based on augmented reality as a valid, practical, and effective media to improve students' cognitive learning outcomes. This research belongs to the type of development research that was developed using the ADDIE model with the stages of analysis, design, development, implementation, and evaluation. The subjects involved in this study were validators, teachers, and fifth grade elementary school students. Data collection was carried out using observation, interviews, questionnaires, and tests. The data collection instrument uses a questionnaire and test questions. Data analysis techniques used were descriptive analysis of qualitative, quantitative, and t-tests. The results of the analysis show that the validation of material experts obtained a percentage of 79.2%, which is included in the valid criteria. The second criterion, which is practical, was obtained through the teacher questionnaire and small group trial. Students obtained a percentage of 88.7% included in the very practical criteria, and the student questionnaire obtained a percentage of 89.5% included in the very practical criteria. The teacher and student questionnaires during the large group trial for teachers obtained a percentage of 91.2% included in very practical criteria and for students obtained a percentage of 88.3% included in very practical criteria. The third criterion is effectiveness. Based on these results, it can be concluded that flashcard media based on augmented reality can significantly improve students' cognitive abilities.

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1. INTRODUCTION

Mathematics is one of the subjects taught at all levels of education, including elementary school, because mathematics forms the foundation for the development of other fields of knowledge (Komariah et al., 2018; Wuyung & Widiastuti, 2020). Mathematics education typically includes topics related to quantities, structures, spatial concepts, and changes within numbers. Therefore, during the learning process, students are required to think critically and creatively in solving problems and questions (Arianti et al., 2019; Rofiqoh et al., 2020). One of the skills developed in mathematics education is children's cognitive understanding, where cognitive ability refers to a child's capacity to think and solve problems using their knowledge and understanding (Erviana, 2019; Indariani et al., 2018). Elementary school students are typically aged between 7 and 12 years old, a stage where they undergo concrete operational development (Afifah & Kusuma, 2021; Umam, 2018). During this stage of development, cognitive abilities in children start to evolve into concrete thinking that is accepted by reason. As a result, children require real or concrete objects in their learning process to enhance their understanding (Dewi & Suniasih, 2022; Irawati & Setyadi, 2021). The success of the learning process can be influenced by various factors, including teachers, students, media, and the learning environment (Al-Maroof & Al-Emran, 2018). Learning media is one of the tools used as a means of communication to convey messages and information related to the teaching and learning activities from educators to learners, thus helping to achieve the learning objectives (Handayani & Abadi, 2020; Widiarti et al., 2021). Learning media has a significant impact on fostering the creativity of both teachers and students by harnessing technology in education to enhance the quality of education and meet the demands of educational technology advancement (Antara & Dewantara, 2022; Rizaldi et al., 2020). The use of media can facilitate teachers in presenting materials, as it can concretize various abstract concepts, making it easier for students to understand the presented content (Arnandi et al., 2022; Octavyanti & Wulandari, 2021).

However, the reality in the field indicates that the teaching process conducted by teachers does not yet make optimal use of instructional media and technology. This has resulted in many students struggling to understand the shapes and formulas of spatial structures, leading to an ineffective learning process and suboptimal cognitive learning outcomes for students. In the process of learning mathematics, each mathematical concept or principle can only be fully understood when the teacher presents the material with the assistance of concrete objects. Therefore, it is crucial to manipulate objects in mathematics education. One of the efforts that can be made to address students' learning challenges is by utilizing augmented reality-based flashcards. Augmented reality-based flashcards are interactive learning media that leverage technology on mobile devices. Augmented reality can display text, video, audio, and other forms of imagery (Adrian et al., 2020; Gandana & Fauziah, 2023). Augmented reality can present 3D objects with the help of flashcards or markers that can be dynamically created, allowing them to change based on the situation or over time (Nirwanto et al., 2021; Sintaro et al., 2020). Markers also enable the use of natural or human-made objects, such as images, as identifiers in augmented reality. Flashcards can enhance students' memory of what they are learning (Munthe & Sitinjak, 2019).

Flashcards have the advantage of being easy to use and practical. They can stimulate the brain to remember information for a longer time and can be easily carried anywhere (Azima et al., 2021; Winangun, 2020). The use of augmented reality-based flashcards in education allows teachers to display objects on a screen in real time with more realistic images. This, undoubtedly, helps students better understand the displayed objects (Pradana & Gerhni, 2019; Wiweka et al., 2021). Several previous studies have revealed that the use of augmented reality in education is significantly effective and provides meaningful learning experiences by combining digital objects to create a sense of the real world (Bistaman et al., 2018). Other research results also show that augmented reality can make classroom learning more engaging and enjoyable and can enhance motivation and the desire to learn (Huang et al., 2019). Furthermore, research has indicated that augmented reality-based flashcards can assist educators in presenting non-monotonous learning materials and help develop students' understanding of the subjects they are learning (Nugraha, 2022). Based on these research findings, it can be concluded that augmented reality-based flashcards have a positive impact on improving students' learning outcomes. However, in previous studies, there hasn't been a specific focus on the development of augmented reality-based flashcards for spatial structure topics to enhance the cognitive learning outcomes of fifth-grade elementary school students. Therefore, this research is focused on addressing this gap with the aim of producing augmented reality-based flashcards as a valid, practical, and effective learning tool to improve students' cognitive learning outcomes.

2. METHOD

This research falls into the category of development research, which is developed using the ADDIE development model. The ADDIE development model consists of five development stages, including analysis, design, development, implementation, and evaluation. The analysis stage in development research is conducted by analyzing the needs of teachers, students, facilities, and learning objectives. Next, in the planning stage, the process involves collecting data on spatial structure material, core competencies (KI and KD), indicators, learning objectives, learning steps, developing objective test questions in the form of multiple-choice, and designing or prototyping media with features such as usage instructions, KI & KD, AR camera, material, sample questions, questions, a researcher profile, and background music. The creation of flashcard media is carried out using Adobe Illustrator for design and augmented reality applications like Blender 3D, Unity 3D, and Adobe Illustrator for augmented reality. After designing the media, the development stage is carried out with the goal of producing a quality product if the design and analysis stages were executed correctly. Once the augmented reality-based flashcard media is developed, it goes through a validation process to determine whether it can be implemented in the next stage. The implementation stage is divided into two phases: a small group trial and a large group trial. The small group trial aims to assess the practicality of the augmented reality-based flashcard media by providing questionnaires to both teachers and students. The large-group trial aims to evaluate the practicality of the media by providing questionnaires to students and teachers. Effectiveness is assessed after students undergo the learning process using augmented reality media, followed by a multiple-choice test consisting of 15 questions within a 40-minute timeframe, covering lower-order thinking skills (C1 - remembering, C2 - understanding, C3 - applying) and three aspects of higher-order thinking skills (C4 - analyzing, C5 - evaluating, C6 - creating). This is used as a benchmark to measure the success of the learning process. Learning outcomes reflect the extent to which students, teachers, the learning process, and the educational institution have achieved the set educational goals.

The final stage of the development process is the evaluation stage, conducted to achieve the development objectives. Evaluation is divided into two types: formative and summative. Formative evaluation is conducted during the development process, while summative evaluation takes place after the completion of the learning activities and any necessary improvements. Formative evaluation allows researchers to revise the instructional media product based on input from content experts and teachers. Summative evaluation serves as a measure of the media's suitability. The development of media is measured through three criteria: validity, practicality, and effectiveness, to assess the quality of high-quality media. The first criterion is validity or relevance, which includes validity. The second criterion is practicality, where the developed media can be applied in the field. The third criterion is effectiveness, where this media is expected to achieve the desired results. The subjects involved in this research include teachers, validators, and fifth-grade elementary school students. Data collection for the development of augmented reality-based flashcard media involves both qualitative and quantitative data. Qualitative data are obtained through observations, interviews with teachers, and feedback from validators. Quantitative data is collected during the feasibility testing of the augmented reality-based flashcard media product. Data are obtained from content experts in the form of validation sheets and are used to determine the responses of teachers and students to the augmented reality-based flashcard media product in the form of questionnaires. Student learning outcomes, in the form of tests, are used to assess the effectiveness of augmented reality-based flashcard media. The quantitative data analysis techniques used include data validation analysis, analysis of the practicality of augmented reality-based flashcards, and analysis of the effectiveness of augmented reality-based flashcards.

3. RESULT AND DISCUSSION

Result

The development of an augmented reality-based flashcard media product for the subject of mathematics is carried out through the five stages of the ADDIE development process. The results of each development stage are as follows: The first stage is the analysis stage. The analysis results indicate that the issues experienced by students during the mathematics learning process include difficulties in understanding the presented material due to the limited use of media by teachers. In the learning process, teachers primarily rely on the use of textbooks and lecture-based teaching methods. Based on these issues, students require media that can concretize various abstract concepts presented in spatial structure materials. The second stage is the design stage. Based on the analysis conducted, the research team designed an augmented reality-based flashcard media. This media is designed using Blender 3D, Unity 3D, and Adobe Illustrator applications. The third stage is the media development stage, which is aligned with the design results. The developed flashcard media has two sides: the first side contains images of spatial

structures, and the second side contains descriptions of these structures. The flashcard is used to display 3D objects through an augmented reality camera. Augmented reality features include core competencies (KI and KD), an AR camera, material, sample questions, usage instructions, profiles, and customizable background music. The results of media development can be seen in Pictures 1, 2, 3, 4, and 5.

Picture 1. Initial Display of the Media

Picture 2. KI and KD Menu

Picture 3. Learning Material Menu

Picture 4. Learning Video Menu

Picture 5. Examples Question Menu

The developed media was then tested for its validity. The validity testing of the media was conducted by content experts, and the validation instrument covered several aspects, including material, language, presentation, questions, construction, media display design, software engineering, and usability, which were assessed according to the evaluation criteria. The result of the validation was 79.2%, which falls within the valid criteria, with comments and improvement requirements. The fourth stage is the implementation of the media product, which is carried out through small group trials and large group trials. Small and large group trials are conducted to determine the practicality of the augmented reality-based flashcard media. Practicality test results were obtained through questionnaires given to teachers and students. The practicality questionnaire received a score of 73 out of a maximum score of 80 for teacher responses, resulting in a percentage of 91.2%, indicating that the augmented reality-based flashcard media is highly practical. The student practicality questionnaire received a percentage of 88.3%, indicating that the augmented reality-based flashcard media is also highly practical. Furthermore, in the implementation stage, an analysis of the pre-test and post-test results of students was conducted with the aim of determining whether the data were normally distributed or not, as one of the requirements for hypothesis testing. Based on the normality test results using the Shapiro-Wilk test, a significance value of 0.003 was obtained, which is less than 0.05. Therefore, it was concluded that the data were not normally distributed. Subsequently, hypothesis testing was carried out using a non-parametric test, namely the Wilcoxon Signed-Rank Test, which yielded an asymp. sig. (2-tailed) value of 0.000, which is less than 0.05. Thus, the "hypothesis is accepted," indicating that there is a difference before and after using the media. The fifth stage is the product evaluation stage, which is carried out by addressing the shortcomings of the developed product.

Discussion

The product resulting from this research is an augmented reality-based flashcard media for teaching the topic of spatial structures in mathematics. The developed media has been revised and is suitable for use in teaching fifth-grade elementary school students. The success of media development is influenced by three factors: First, the developed media falls into the category of being valid because the flashcard-based augmented reality media includes Basic Competencies (KI) and Core Competencies (KD), usage instructions, an AR camera, content, sample questions, researcher profiles, and is equipped with background music, all presented comprehensively as a means of communication to convey messages and information related to the teaching and learning process, thereby achieving the learning objectives. Flashcards are cards with two sides, the first side containing words and the second side containing corresponding images (Gandana & Fauziah, 2023; Munthe & Sitinjak, 2019). Augmented Reality (AR) can display virtual 3D objects in the real world, allowing users to explore new environments and experience virtual objects as if they were real (Huang et al., 2019; Yip et al., 2019). The use of augmented reality with smartphones can display text, video, audio, and other image forms (Lubis & Dasopang, 2020; Wibowo et

al., 2022). The combination of flashcards and AR technology uses flashcards as markers to trigger 2D or 3D objects, enabling students to interact with these objects from various perspectives. Teachers using flashcards and AR technology can display objects on a screen in real time with more realistic images (Munthe & Sitinjak, 2019). helping students understand the displayed objects (Pradana & Gerhni, 2019). Second, the augmented reality-based flashcard media developed falls into the highly practical category. The use of flashcards that can display 3D objects through an AR camera is combined with an attractive design and the inclusion of spatial structure formulas, making it easier for students to understand the material. This is because flashcards are practical to use, stimulate the brain to remember information for a longer time, and are easily portable (Azima et al., 2021; Munthe & Sitinjak, 2019). Flashcards are practical for stimulating student development because they contain learning material to stimulate students' development (Azima et al., 2021; Bistaman et al., 2018). The practical use of flashcards, combined with AR technology's concise features, can facilitate students in understanding of the material and its application. Utilizing technology in education, including AR as an interactive medium, can simplify and enhance the learning process. Interactive media that combines various forms of media can be used for both independent and classroom learning, making it accessible to students with different levels of ability without difficulty in understanding the subject matter (Handayani & Abadi, 2020; Widiarti et al., 2021). Interactive media is also practical to use as a supplement to the learning process.

Third, the developed media is effective in improving students' cognitive abilities. Cognitive ability refers to a child's ability to think and solve problems by utilizing their knowledge and understanding. Elementary school students are in the age range of 7-12 years, where they are in the stage of concrete operational development (Afifah & Kusuma, 2021; Umam, 2018). During this stage, children's cognitive abilities begin to develop into concrete thinking and are accepted by reason, so children need real or concrete objects in their learning process to help improve their understanding (Dewi & Suniasih, 2022; Irawati & Setyadi, 2021). Augmented reality media is highly suitable for stimulating the development of cognitive abilities in children because it can provide an active and interactive learning environment (Nirwanto et al., 2021; Sintaro et al., 2020). Positive attitudes are obtained through increased interest and motivation generated by users and the ability to explore content deeply, leading to increased motivation among students compared to their condition before using AR. The results obtained in this research align with previous research findings, which also indicate that the use of augmented reality in education has significant effectiveness and provides meaningful learning by combining digital objects to create real-world reality (Bistaman et al., 2018). Other research results also indicate that the use of augmented reality can make classroom learning more interesting and enjoyable and can increase motivation and enthusiasm for learning (Huang et al., 2019). Another research finding indicates that augmented reality-based flashcards can help educators present non-monotonous learning media and can help develop students' understanding of the material (Nugraha, 2022). Therefore, based on several research findings, it can be concluded that augmented reality-based flashcards have a positive impact on improving students' learning outcomes.

4. CONCLUSION

Based on the analysis of data and discussions, it can be concluded that the augmented reality-based flashcard media developed has met the criteria of validity, practicality, and effectiveness for use in teaching mathematics, specifically spatial structures, to fifth-grade students in Elementary School.

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