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The Augmented Reality Based Flashcards for Learning Heat and Thermodynamics in High School

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Abstract

The objective of this study is to create augmented reality flashcards for teaching heat and thermodynamics to 11th grade students. These flashcards will be used in the classroom during learning sessions for 11th grade science students. The work was executed utilizing the Alessi and Trollip methodology, which encompasses the stages of planning, design, and development. The data were obtained by means of expert validation and a response questionnaire. The findings indicated that the material had a validity rate of 92% and fell into the category of being highly valid. Similarly, the media had a validity rate of 86.95% and also fell into the highly valid category. Therefore, the product gets a validity rating of 89.47% and falls into a very valid category. The practicality score during the first stage of the beta test was 89.2%, with a specific focus on the practical category and a sample size of 4 students. In the second stage of the beta test, the practicality score decreased to 86.27%, with the same focus on the practical category but with a larger sample size of 10 students. The teacher's answer to the practical category yielded a score of 87%. Therefore, the flashcard product utilizing augmented reality for the subject of heat and thermodynamics in the 11th grade of high school could be used for learning purposes.

Keywords: flashcards, augmented reality, physics learning

INTRODUCTION

The development of the industrial era 4.0 has entered the world today and these changes are inevitable so that it is necessary to prepare in terms of adequate human resources (HR) in order to compete on a global scale (Mahmudah & Putra, 2021). Revolution 4.0 is characterized by the fusion of technology and blends the lines of physical, digital and biological space (Putriani & Hudaidah, 2021). Industry 4.0 is largely influenced by the use of digital technologies and data analytics (Karim et al., 2020). Education 4.0 is seen as an educational innovation that can build a high education system (Chaka, 2022). Human resource skills in industry 4.0 give manufacturing processes the obligation to layer interactive ingenuity into systems along with AI and information technology (Umachandran et al., 2019). Utilizing technology in learning in the industrial revolution 4.0 is one way to help students adapt to it (Alimuddin et al., 2023).

Advances in information and communication technology (ICT) not only increase the scope of education through e-learning but there are several platforms that can be used such as Augmented Reality (AR), Virtual Reality (VR) and mobile learning (m-learning) (Nistrina, 2021). Education is influenced by advances in information and communication technology. The educational environment is one that greatly benefits from technological advances because it provides tremendous benefits such as exploration of learning materials, journals, books and building discussion forums (Khotimah et al.,

2019). Through the use of learning media, learning is a collaborative process between teachers and students. Learning objectives that are hampered by the lack of learning resources and media, require the development of techniques to improve learning, one of which is the use of learning media as a delivery mechanism (Firmadani, 2020). Educational software development allows teachers to deliver the latest learning science advancements (Escueta et al., 2017).

The rapid entry of technology into the world of education is starting to play a major role in the success of the learning process, one of which is augmented reality (Lin & Yu, 2023). Software development in education allows educators to deliver the latest advances in learning science (Escueta et al., 2020). This technology has been used to offer solutions to problems faced by educators and to create learning environments that are interactive and can be an advantage in improving student learning. In addition, in the field of games, AR causes many users to waste time using a cell phone as a device to play with AR technology (Permana et al., 2021). Augmented reality is a technology that combines the real world and the virtual world through devices and software that allows the presentation of 2D and 3D images, graphics, and text displayed through devices such as computers, cell phones, tablets and other devices (Soutthaboualy et al., 2022; Seetohul et al., 2023). Technology becomes materials and tools for the learning process (Agustian & Salsabila, 2021). The utilization of AR technology can be applied with flashcard learning media to display material concepts in physics learning. Flashcards are an appropriate and easy way to use visual tools to help students learn (Chotimah, 2021; Rahman et al., 2023).

The use of flashcards in learning has shown that learning with flashcards has a positive influence (Ying et al., 2021). The flashcard learning model is a learning system that instills social skills, especially the ability to work together and the ability to interact (Fitriani et al., 2021). Applying theoretical analysis to flashcards can explain that flashcards can target different levels of information (Lin et al., 2018). The feasibility and innovation in Augmented Reality is also the interaction of humans and computers so that with the increase in computing power of computer software and hardware (Chen et al., 2019). AR works through a device that exposes the real world and inverts virtual objects in real time (Elmqaddem, 2019; Pochtoviuk et al., 2020). AR innovation has the potential to significantly improve education, the technology is also limitless and will enable efficient and effective real-time navigation (Gudoniene & Rutkauskiene, 2019).

Based on the results of the analysis of student needs, it was found that 37.5% of students did not know and heard of flashcard media or augmented reality and 92% of students agreed that augmented reality-based flashcards were more interesting to use during learning. This underlies the researcher to develop augmented reality-based flashcards.

METHODS

This research uses a research method used in this research is development research. In the field of education, development research is a research method used to develop or validate products used in education and learning (Ikhbal & Musril, 2020). This research aims to produce a flashcard media based on augmented reality that is valid and practical. The development research model used in this research is the Alessi and Trollip development model which consists of the planning stage, the design stage, and the development stage. The Alessi & Trollip model has more concise stages and consists of detailed sub-components. The subjects of this research were students of grade 11th. The application of the development steps is adjusted to the needs of the researcher, so the steps are simplified as follows: conducting data collection, namely by analyzing student needs, planning research, product development, initial product testing, namely by product validity by material experts and media experts and revising the results of the validity test, conducting beta test 1, namely by trying one to one, revising beta test 1 followed by beta test 2, namely small group. The development research steps used are shown in FIGURE 1.

The stages of development using the Alessi and Trollip model are: The first stage is the planning stage. At this stage, identifying the scope by identifying student characteristics and determining subject sources is carried out. In the second stage of making design, in this second stage, the development of ideas / ideas of initial content in augmented reality (AR) based flashcard media products is carried out, analyzing concepts, and making flowcharts and storyboards.

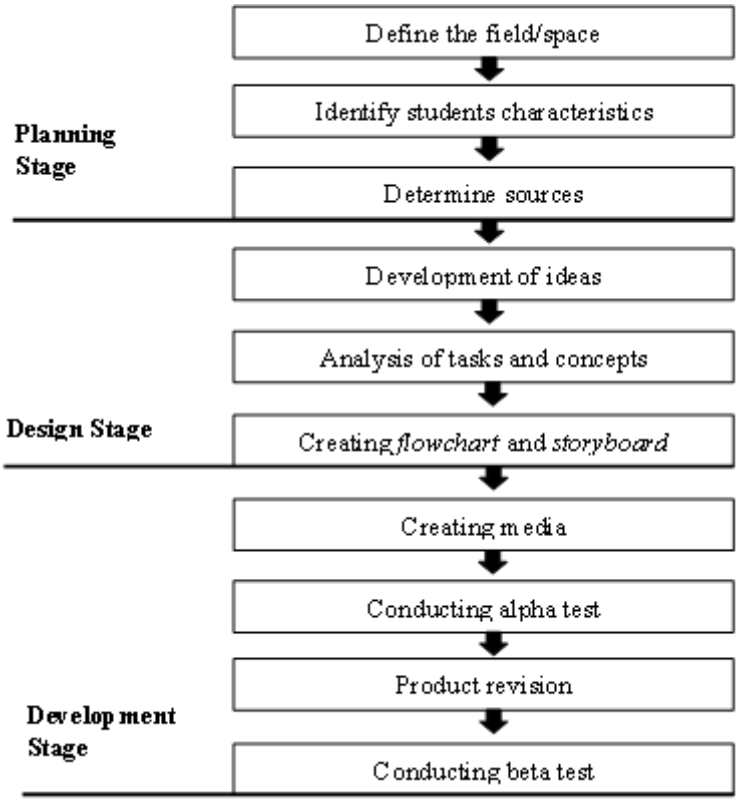

FIGURE 1. Development Procedures of Alessi and Trollip

The third stage is the development stage, this stage makes the product in the form of augmented reality-based flashcards on heat and thermodynamic material for class XI SHS. In this stage, material collection is carried out that can support product development and then collect several videos and objects. After making the product, alpha testing and beta testing are carried out. The interpretation of validity values is presented in TABLE 1.

TABLE 1. Content Validity Interpretation

% (validate)	Category
0-20	Invalid
21-40	Not valid
41-60	Quite valid
61-80	Valid
81-100	Very valid

The tabulated results were searched for the percentage using the EQUATION 1.

$$p = \frac{\sum item\ score}{maximum\ score} x\ 100\% \quad (1)$$

The interpretation of the practicality score is presented in TABLE 2.

TABLE 2. Content Practical Interpretation

% (practical)	Category
0-20	Impractical
21-40	Less practical
41-60	Quite practical
61-80	Practical
81-100	Very pratical

The tabulated results were searched for the percentage using the formula:

$$p = \frac{\sum item\ score}{maximum\ score} x\ 100\% \quad (2)$$

RESULTS AND DISCUSSION

Planning

The initial stage was to identify the needs. The needs obtained from one of the school in Palembang city which has adequate facilities. Based on these observations, it shows that the use of learning media more often uses printed media and displays videos from YouTube. This is because teachers are less creative in utilizing learning media. Along with the development of increasingly sophisticated technology, teachers should be able to explore various interesting learning media to convey.

Design

At this stage, development is carried out based on the information that has been obtained, namely by determining the objects developed in augmented reality-based flashcard learning media. The objects, namely the use of text, sound, images, animation and design. All these objects become a sequence of interconnected displays in the learning media. The next step is to create a flowchart. Flowchart is a visual representation of a sequence of steps or processes in the form of graphical symbols. Flowchart helps in visualizing the workflow or procedure of the augmented reality-based flashcard media product developed.

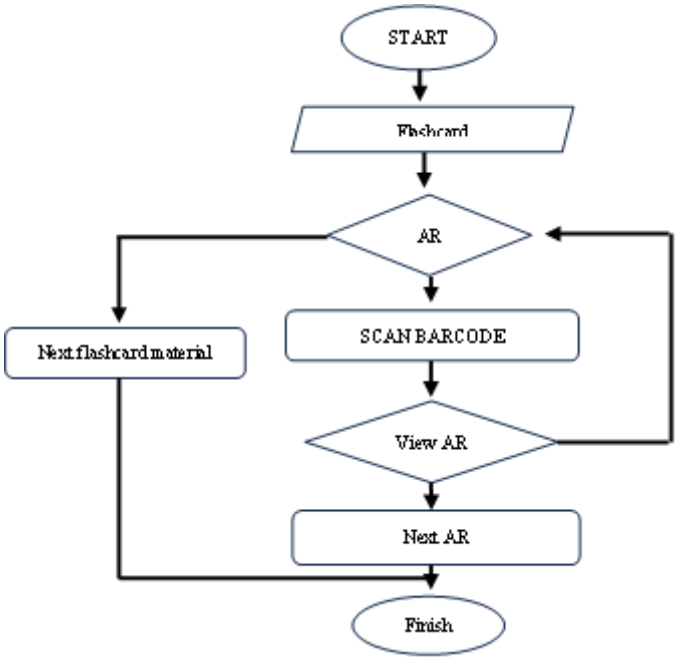

FIGURE 2. Flowchart

In the next stage, the process of making augmented reality-based flashcard media that has been conceptualized with a storyboard is carried out. The process of making learning media is done by making flashcards using the Canva application. The size of the flashcards used has been varied, namely 7.5 cm x 10.5 cm. The thickness of the flashcard paper used is 260 and additional laminating. Furthermore, designing augmented reality using the assmblr edu application.

The Augmented Reality-based flashcards developed are equipped with a design that can be seen in FIGURE 3.

FIGURE 3. Design of Flashcard Based Augmented Reality

Development

At the development stage, the researchers made improvements to the augmented reality-based flashcards that had been produced through material and media validation. At the validation stage, augmented reality-based flashcards were tested for feasibility by 3 experts (2 media experts and 1 material expert). The total number of flashcard pages is 36 pages. The material of heat and thermodynamics produced 10 AR barcodes. Some ARs are equipped with animated videos to explain thermodynamics while 3D animations to show the application of heat in everyday life. The results of the study can be seen in the table of validity results of media experts and material experts or content on augmented reality-based flashcards.

TABLE 3. Media expert validation result

Validator	Σ *skor*	Σ *skormaks*	Percentage	Category
expert 1	103	115	89.56%	Very valid
expert 2	97	115	84.34%	Very valid

After studying the material of heat and thermodynamics, students are expected to be able to; 1. Explain the concept of heat and thermodynamics; 2. Use the daily life application of heat and thermodynamics; 3. Use the principle of black principle to solve physical cases. 4. Use the principle of thermodynamics application to solve physics cases in daily life. Meanwhile, after exploring the material of heat and thermodynamics, students are expected to be able to use the principle of entropy. Students can formulate entropy changes, namely for isolated systems and non-isolated systems. From the results of media expert validation, the percentage value is 86.95% with a very valid category. In

accordance with the validation criteria used in the expert validation table, if the score obtained is 81-100%, the media is declared very valid for use.

The use of augmented reality-based flashcards is considered more effective. The time for barcode transfer is faster to show that AR is more effective and efficient than students having to search for animations on YouTube. In research conducted by (Winda et al., 2023) using AR can train students' creative thinking and can be a new educational trend.

TABLE 4. Material or content expert validation results

Validator	Σ *skor*	Σ *skormaks*	Percentage	Category
expert	69	75	92%	Very Valid

The results of the assessment of content experts or learning media materials contained in TABLE 4 can be calculated as a percentage of the level of achievement as EQUATION (3).

$$p = \frac{\sum skorper'item}{skormaks} x\ 100\% \quad (3)$$

Since the weight of each choice is 1, the percentage:

$$p = \frac{69}{75} x\ 100\% = 92\%$$

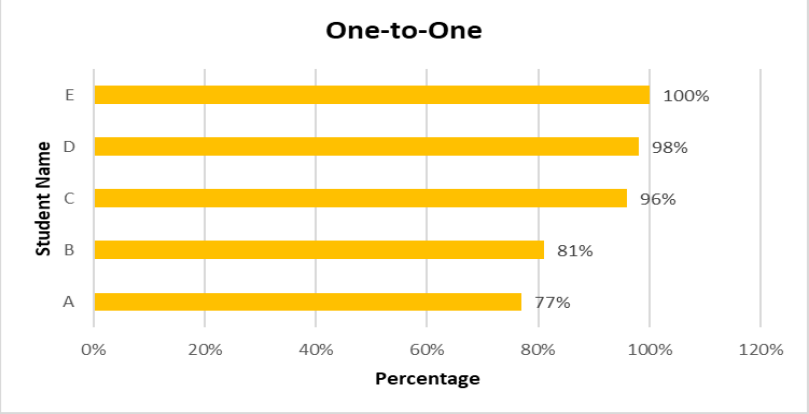

FIGURE 4. Beta test student response result 1

The diagram above shows that student responses at the beta test stage 1 strongly agree to the use of augmented reality-based flashcards as an alternative learning media in the classroom in physics subjects. The results of the initial trial of augmented reality-based flashcard media were 90% of students gave a positive response to the questionnaire, the percentage classified as "very practical". Beta 1 trial involving 5 students was conducted to see the practicality on a small scale.

Therefore, minor improvements are made to the augmented reality-based flashcard product and can be continued to the small group stage to see the assessment of students from different classes.

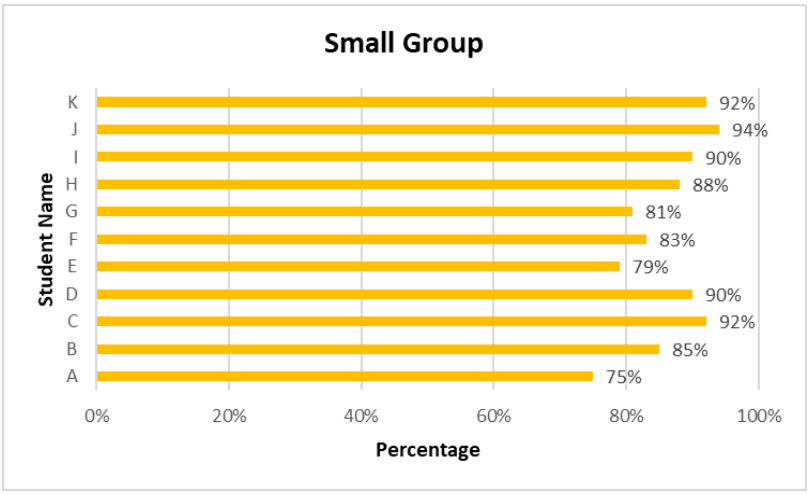

FIGURE 4. Beta test student response result 2

The diagram above shows that student responses at the beta 2 (small group) test stage regarding augmented reality-based flashcard media strongly agree to the use of media in the classroom in physics subjects. The results of the beta 2 trial involving 11 students showed 86.27%, the presentation was classified as "very practical". These results indicate that the use of learning media can make students feel comfortable.

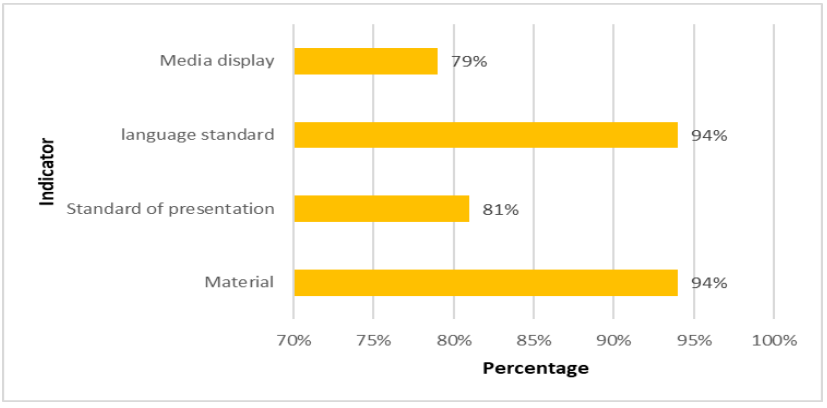

FIGURE 5. Teacher response results

The diagram above shows that the Physics teacher's response strongly agrees with the use of augmented reality-based flashcards as an alternative learning media in the classroom. Based on this diagram, the percentage level of achievement is 87%. In accordance with the criteria of practicality used 81-100% very practical category.

Previous research states that the advantages of using augmented reality (AR) media can increase student engagement, increase material understanding, and student collaboration (Kuswinardi et al., 2023). Other studies have also shown that learning media using flashcards can increase motivation and concept understanding of high school students (Setyawan, 2019).

Development of learning media using technology, only a few teachers have known and understood the concept of augmented reality learning media (Siahaan et al., 2023). This shows that there are still very few teachers who use and even develop multimedia in delivering science concepts in learning.

An educator in the learning process can use several learning media to facilitate students and must be able to utilize learning media so that the learning process does not experience difficulties, so development efforts need to be made. From several types of media, the selection of the use of learning media must be adjusted to the conditions and achievement of learning objectives. The meaning of conditions in media selection is in accordance with the ongoing situation and in accordance with the abilities possessed by students (Siahaan et al., 2023). So that the development of learning media is very

necessary to be applied to learning, in this study of course still has limitations in the implementation of its stages so that further research is needed to improve the understanding of the concepts of high school students.

CONCLUSION

Based on the results of research on Augmented Reality-based Flashcard products for grade 11th, can help students in learning the material of heat and thermodynamics. In this development, the heat and thermodynamic material developed consists of heat capacity material, black principle, changes in substance form, heat transfer, application of laws 1 and 2 of thermodynamics. Flashcards consist of 38 pages and produce 10 AR products which are a combination of 3D animation and video. Material and media experts have validated AR-based flashcards with very valid categories. Meanwhile, the results of the alpha and beta tests were very practical. These results indicate that the AR-based flashcards developed are very feasible to use as learning media that help students in learning activities. However, for further researchers it is recommended that it needs to be developed for the effectiveness test of augmented reality-based flashcards.

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