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DESIGN OF MODULE BASED INTEGRATED AUGMANTED REALITY (AR) ON ENERGY TRANSFORMATION MATERIAL TO TRAIN CREATIVE THINKING SKILLS OF ELEMENTARY SCHOOL STUDENTS

NOVARIA LAILATUL JANNAH[1], W. WASIS[1,*], W. WIRYANTO[1], S. SURYANTI[1], WAHONO WIDODO[1], ARIE WIDYA MURNI[1], LAELY FAROKHAH[2], AMADHILA ELINA PENEHAFO[3]

[1]Universitas Negeri Surabaya, Surabaya, Indonesia
[2]Universitas Pendidikan Indonesia
[3]Namibia College of Open Learning, Namibia
*Corresponding Author: wasis@unesa.ac.id

Abstract

This research aims to develop an augmented reality (AR) based learning module on energy transformation material to train elementary school students' creative thinking skills. The method used is design-based research (DBR) which involves four phases: needs analysis, initial solution development, iterative, and reflection. The results of the study showed that AR based modules were effective in increasing student engagement during learning and sharpening understanding of the concept of energy transformation. The discussion of this study shows that the use of AR technology not only attracts students' attention but also encourages creative thinking skills in solving problems related to energy transformation material. The impact of this research shows the potential for expanding the use of AR modules in other subjects to train higher-order thinking skills. Future recommendations are to conduct further development at various grade levels and integrate AR modules with technology-based learning strategies to improve learning effectiveness, especially in elementary schools.

Keywords: Augmanted reality (AR), Creative thinking skills, Elementary school, Energy transformation material, Learning module.

1. Introduction

Students should be encouraged to not only be able to master knowledge but also be able to practice creative thinking in solving various problems [1]. One technology that is starting to be widely applied is Augmented Reality (AR), which is able to integrate virtual objects into the real world, thus creating a more immersive and enjoyable learning experience [2]. In energy transformation material, the use of AR-based modules not only helps students understand abstract concepts but also stimulates creative thinking skills through deeper and interactive exploration. Creative thinking skills are particularly important to develop from elementary school age [3]. Thus, the design of AR-based modules in science learning is expected to be an effective method in supporting the achievement of fun learning goals in elementary schools, especially in developing 21st century skills.

AR-based modules allow students to learn more interactively and visually, thus increasing their interest and engagement in the learning process [4]. In addition, AR has been shown to be effective in stimulating creative thinking skills because students are invited to observe, analyse, and solve problems independently through a more in-depth learning experience [5]. In the energy transformation material, the use of AR can help students understand concepts that are often difficult to understand through conventional learning alone [6]. The design of modules that integrate AR also allows students to build creative skills that are essential in developing 21st-century skills [7]. Thus, the application of AR in basic education is one of the innovative solutions to improve the quality of learning and student skills [8].

The purpose of this study is to develop an augmented reality (AR) based module on energy transformation material to train elementary school students' creative thinking skills. This module is expected to be able to present interactive and in-depth learning, making it easier for students to understand abstract energy concepts in a more visual and real way. The novelties of this study lies in: (i) the design of a module that uses AR for science learning in elementary schools, especially on energy transformation material; and (ii) focusing on the development of a module that trains elementary school students' creative thinking skills.

2. Literature Review

Augmented Reality or AR is a technology that allows users to see virtual objects images, videos, or animations in the real world using a smartphone or tablet. In other words, AR allows for a more immersive experience because it involves digital elements by viewing the real world. In general, learning using AR helps students see concepts that are difficult to visualize in a more abstract representation [9-11]. Application of Augmented Reality (AR) in learning, especially in elementary school learning, has shown great potential in helping students understand abstract concepts in science subjects, including material on energy transformation. AR allows for visual and interactive depictions that make it easier for students to visualize complex processes, such as changes in energy forms. AR technology can improve students' understanding of science concepts by providing clearer and more engaging dynamic representations, thus facilitating deeper learning [12].

Creative thinking skills include the ability to identify relationships between different concepts and generate innovative solutions, which can be fostered with AR. AR-based learning offers an interactive experience that allows students to

explore new ideas and conduct virtual experiments. found that the use of AR in science education not only improves students' understanding but also encourages students to develop creative thinking skills through independent exploration and manipulation of virtual objects [13]. Creative thinking skills also have several indicators, namely the ability to generate new ideas (fluency), the ability to think flexibly (flexibility), the ability to think of new ideas (originality), and the ability to elaborate ideas (elaboration). Creative thinking skills are particularly important to train in elementary school students [14].

The context of energy transformation material taught in grade 4 in the phase B curriculum, in Fig. 1 this material discusses how energy can change from one form to another, for example chemical energy into heat energy or electrical energy into light energy. This material helps students understand the basic principle that energy cannot be created or destroyed, only changed form according to the law of conservation of energy [15].

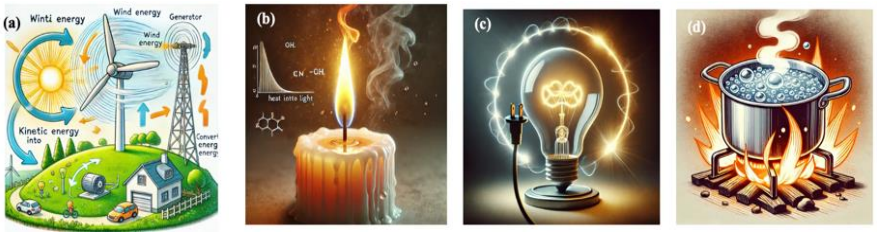

Fig. 1. Transformation energy, (a) Mechanical energy, (b) Chemical energy, (c) Electrical energy, (d) Thermal energy.

This learning provides a more real and relevant experience for elementary school students. The integration of AR in science learning significantly improves students' conceptual understanding and contributes to the development of creative thinking skills [16]. The following is a mapping to illustrate energy transformation.

Figure 1 transformation energy it can be seen and provides a visualization of the types of mechanical energy with examples of (a) wind drives a turbine, changing kinetic energy into electrical energy, in the type of chemical energy an example of energy transformation is given; (b) fuel (chemical) changes into heat and light (candles are burned); then in the type of electrical energy an example of energy transformation is given (c) lamps use electrical energy to change into light; in the type of thermal energy an example of energy transformation is given (d) heat from fire is used to heat water.

3. Method

This study uses the Design-Based Research (DBR) research method, the following are the stages used in the DBR research method: (i) Needs Analysis, (ii) Initial solution development, (iii) Iterative, (iv) Reflection. In the needs analysis stage, it shows that an Augmented Reality (AR)-based module on energy transformation material in elementary schools is needed to improve understanding of abstract concepts, motivate students through visual interaction, and overcome the limitations of physical teaching aids in learning, and foster creative thinking skills of elementary school students. Therefore, the researcher made the development of

an AR integrated module. The Development stage includes designing content that is adjusted to the independent curriculum in phase B of grade 4 of Elementary School, after which the creation of an AR module prototype that visualizes energy transformation material, then validated by media experts and tested limited to 44 elementary school students at SDN Magersari. The problem limitations in this study are focused on the development of AR modules only for energy transformation material in elementary schools with the main aim of practicing creative thinking skills.

4. Results and Discussion

Needs analysis shows that learning in elementary schools often faces challenges in facilitating students' understanding with the presence of abstract concepts that are difficult to visualize, making students tend to be less actively involved in the learning process, thus their high-level thinking skills, especially their creative thinking, are not well trained. In addition, the use of conventional learning media such as textbooks, worksheets, and physical teaching aids is still limited. To train creative thinking skills requires more innovative learning methods and supports active student involvement. Previous research shows that learning in elementary schools still tends to be dominated by conventional methods that provide less opportunities for students to develop their creative thinking skills [17].

Opening the Assemblr application is considered to be the starting process in the flowchart in Fig. 2, "Flowchart of the AR Energy Transformation Module." When the application has opened, a user selects the scan menu and points towards the barcode given in the module. The position of each of the barcodes is crucially indicated to be on top of certain areas at the energy transformation page to trigger a certain augmented reality visible content. This serves as a cue to dynamically show 3-D models or interactive animations illustrating the energy transformation processes. The intuitive design means that there are no problems in using the material, which further reinforces how complex concepts are learnt. Moreover, the module is user-friendly in design and clearly leads learners at every stage of the process. It enables learners to work within an AR-enhanced module for a better and more interactive learning environment. Moving in that direction, apart from enhancing different learning styles, also help in making abstract concepts more tangible.

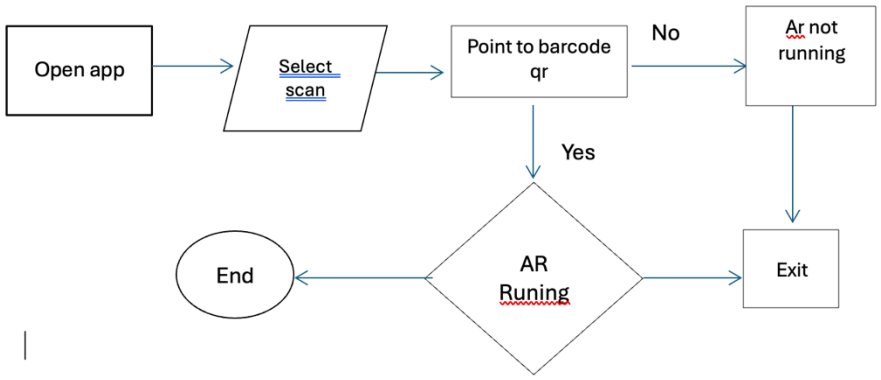

Fig. 2. Flowchart use of AR in energy transformation modules.

Describes the flow of operation of the Augmented Reality (AR) module which starts from the user opening the application (Open App) and selecting the option to scan (select scan). After that, the device is directed to the QR code (point to barcode QR). If the QR code is not detected, the application would not run the AR feature and provide an option to exit (EXIT). If the QR code is detected correctly, the AR feature would run (AR Running), and the flow would end after the process is complete.

The process of creating an AR integrated module with energy transformation material begins with content planning by looking at the material in the elementary school curriculum in phase B of grade 4 of Elementary School. There are abstract concepts that students do not yet understand, such as heat energy into kinetic energy or heat energy converted into Light energy. The content is designed in a module, after the module is arranged as desired, the next step is to develop an AR application by including 3D visual elements that can be scanned using a mobile device or tablet via a QR code. Furthermore, the module validated by a media expert, thus this prototype can be tested on a limited basis in elementary schools.

AR can help in understanding these complex concepts by offering interactive and visual depictions, which are more effective than traditional methods [4]. Studies have shown that AR-based learning environments can improve students' conceptual understanding and engagement by offering immersive and interactive learning experiences [18]. Furthermore, AR supports students in visualizing abstract scientific phenomena, making it easier for them to grasp difficult concepts such as energy transformations [6]. In Fig. 3 is the result of developing an AR-based module. The content is designed in a module, and after the module is arranged as desired, the next step is to develop an AR application by including 3D visual elements that can be scanned using a mobile device or tablet via a QR code. AR allows learners to interact with 3D models, which has been shown to increase engagement and motivation [7]. Additionally, AR modules are effective in building essential 21st-century skills, including creative problem-solving and critical thinking [3]. The AR application is validated by a media expert to ensure its functionality and effectiveness, allowing for a limited test in elementary schools.

Fig. 3. Results of the energy transformation module, (a) Cover energy transformation module, (b) One of the AR in progress.

The development of this AR module is still far from perfect, many inputs from the validations helped provide suggestions, thus the module is more suitable for use during learning. For sustainability, developed even better with the presence of 3D that can move to provide real visualization of the process or how it works in a tool in changing energy in household furniture or equipment in the surrounding environment, for example how a fan works, which changes electrical energy into kinetic energy.

The results of the development of the Augmented Reality (AR) module on the material of energy transformation showed a significant increase in students' understanding of concepts and creative thinking skills in elementary schools. With significant effectiveness results obtained in this AR-based module because it has received material validation and media validation by material experts and media experts and has been tested on elementary school students at SDN Magersari, validation shows suggestions and improvements to be better in its use [19, 20]. AR in this module presents a more interactive and enjoyable learning experience, allowing students to observe and identify energy transformation phenomena directly through 3D visualization. It strongly supports learning because students can manipulate virtual objects and understand abstract concepts such as energy conversion from one form to another more easily. According to the theory of cognitivism, AR technology allows students to be involved in an active learning process, students not only receive information passively but are also directly involved in the learning process, which leads to increased conceptual understanding [21, 22]. This is in line with previous research showing that the use of AR technology in education increases student engagement and facilitates more contextual and relevant learning [23]. AR in education provides opportunities for students to visualize difficult objects and concepts, increasing motivation and learning engagement [8].

This AR-based module also has a positive influence on training creative thinking skills. In constructivism theory, experiential learning helps students to build students' understanding of knowledge based on active interaction with the surrounding world [24]. The use of AR significantly improves students' ability to understand and apply science concepts, as well as fosters creativity in students' learning process [25, 26]. Finally, this study adds new information as reported elsewhere [27].

5. Conclusion

Through this research, an AR-based learning module has been developed on the material of energy transformation that effectively helps sharpen students' conceptual understanding. The development of this AR-based module design was developed with four stages of design-based research (DBR), namely needs analysis, initial design, iterative, and reflection. The AR-based module helps students visualize and run simulations to support in practicing strong creative thinking skills. The findings of this study are that AR technology can still be utilized in other materials to promote several other thinking skills. For further research, it may be expanded to various grade levels and can also be aligned with new learning strategies.

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