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DEVELOPMENT OF AUGMENTED REALITY LEARNING E-MODULE BASED ON TDBA - RADEC TOWARDS IMPROVING STUDENTS' ENVIRONMENTAL LITERACY TO SUPPORT SUSTAINABLE DEVELOPMENT GOALS (SDGS)

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Abstract

This study aims to examine the effectiveness of learning through augmented learning (AR) integration. AR Tatanén-based Bale Atikan (TdBA) is an environmental pedagogical approach that collaborates on local wisdom with the read, answer, discuss, explain, create (RADEC) learning model in fostering environmental literacy in elementary school students. Departing from the ecological context of elementary schools, this study uses a quasi-experimental design, which combines quantitative data from the pretest-posttest with qualitative observations, interviews, and reflective documentation of the learning process carried out in an open environment. The results of the study indicate that e-module learning based on integration between TDBA and RADEC can create a transformative learning experience, which not only develops students' conceptual understanding, but also attitudes and skills that reflect ecological awareness, because various activities such as direct exploration of local biodiversity, observation of environmental changes, and simple conservation practices become authentic learning contexts that connect students' life experiences with scientific life and environmental responsibility. The RADEC model strengthens structured cognitive engagement, while the TdBA approach instils cultural values and local wisdom; the combination produces a holistic pedagogical framework that encourages increased environmental literacy. Finally, this study adds new information regarding sustainable development goals (SDGs).

Keywords: Augmented Reality, E-module, RADEC, SDGs, TdBA.

1. Introduction

The importance of environmental literacy is reflected in various research findings that emphasize that the younger generation needs to be equipped with knowledge, skills, and attitudes of environmental concern as social capital in facing global challenges, such as climate change, contamination, and ecosystem damage [1, 2].

The main focus of this research is to examine in depth the effectiveness of implementing augmented reality (AR) e-module-oriented learning as a learning strategy integrated with the AR Tatanén-based Bale Atikan (TdBA) approach, a form of learning developed through a collaboration of educational principles with local community wisdom. This integration is then combined with the RADEC learning model [3, 4]. Thus, it can create a more contextual and meaningful learning experience [5-7].

The method in this study used a quasi-experimental design, which combines quantitative data from pretest-posttest with qualitative observations, interviews, and reflective documentation of the learning process carried out in an open environment. The novelty of this research lies in the use of Tatanen in Bale Atikan, a learning model that is relatively new and has not been widely implemented. The combination of RADEC-based TdBA learning with AR is a strategic innovation that supports students in increasing awareness and literacy on environmental issues. This study also combines TdBA learning with RADEC using an Augmented Reality E-module. This integration has never been studied specifically, especially in environmental literacy. Finally, this study adds new information regarding sustainable development goals (SDGs).

2. Literature Review

Figure 1 explains that the application of Augmented Reality in the RADEC TdBA learning integration can improve environmental literacy. This is in accordance with the experiential learning approach, where students not only receive information but also experience it visually and practically [8]. AR can be seen as an important instrument in developing 21st-century competencies. AR can enrich the learning experience by presenting more concrete and interactive visual representations [9]. The use of AR technology that integrates virtual objects into the real world in real-time allows users to interact with digital information in the context of their environment [10]. AR can also display three-dimensional plant growth simulations, so that students gain a deeper understanding of complex environmental concepts [11]. The integration of the AR E-module in the RADEC and TDBA learning model provides an effective learning innovation in improving students' environmental literacy. RADEC emphasizes active learning activities ranging from reading to creating [12], while TDBA is rooted in local wisdom with an emphasis on real practices and environmental awareness [13].

The RADEC learning model is an approach developed by Sopandi as an alternative to active learning that emphasizes comprehensive student involvement in the learning process [14]. RADEC starts from the assumption that meaningful learning occurs when students not only receive information but also actively construct knowledge through a series of structured stages.

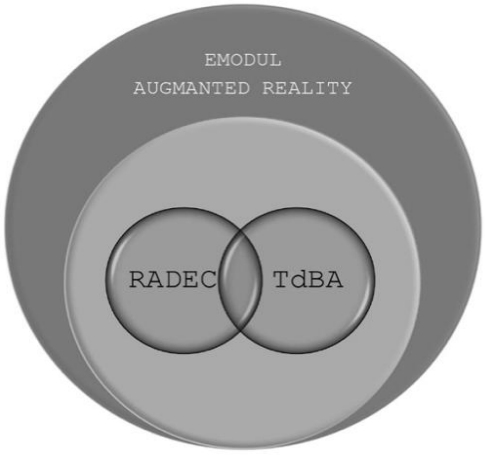

Fig. 1. AR Emodule-based learning concept based on RADEC TDBA.

The RADEC stages consist of five main steps [14]: (i) Read: Students read materials or learning resources related to the topic to gain a basic understanding; (ii) Answer: Students answer questions prepared by the teacher based on the reading material to establish their initial understanding; (iii) Discuss: Students discuss their answers with their peers to broaden their perspectives and clarify concepts, (iv) Explain: Students explain their discussion results to the class, fostering scientific communication skills and deeper understanding, and (v) Create: Students produce work or products as a form of application of their acquired knowledge.

A contextual learning model initiated by Purwakarta as an effort to integrate local wisdom into education. The term "tatanén" means "to cultivate or farm," while "bale atikan" means "house or study space." Thus, TdBA can be understood as a learning approach that links learning activities with agricultural practices, the environment, and local culture by Purwakarta Education Office. Through TdBA, students are invited to learn directly in nature, cultivating land, planting, maintaining, and harvesting crops, so that the learning process is not only cognitive, but also psychomotor and affective [15].

3. Research Methods

This study used a quantitative approach with a quasi-experimental design conducted at an ecological elementary school in Purwakarta Regency with a composition of 30 students. Detailed information regarding this study is explained elsewhere [16, 17]. The methodology of this study used a quasi-experimental approach with a design involving an experimental group and a control group, but without a randomization process in determining the subjects for each group. The experimental group received certain treatments or interventions, while the control group did not receive any intervention. The research instruments consisted of an environmental literacy test, a student activity observation sheet, and a student response questionnaire to learning. The environmental literacy test measures aspects of environmental knowledge, attitudes, and skills. The validity value obtained for all aspects was above 0.70, while the reliability value above 0.80 indicates that the instrument is very suitable for use.

4. Results and Discussion

Figure 2 explains the development of Augmented Learning Media. AR is a structured process that involves preparation, production, and post-production. The preparation phase begins with a literature review and exploration of various learning videos. This phase also involves evaluating various AR tools or toolkits. Furthermore, creating a basic storyboard of the AR flow is a crucial step in mapping out the interactive scenarios to be presented. The involvement of teachers and subject matter experts is essential to ensure the content developed is accurate, relevant, and aligned with learning objectives. The next stage is production, which focuses on the technical aspects and visualization of the media. This process begins with designing the graphical elements of the user interface, creating textures and mapping, and modifying visual elements according to platform requirements. Three-dimensional modeling is then performed to produce representations of objects to be used in AR. If the media is deemed suitable and meets the criteria, the development process proceeds to the final stage.

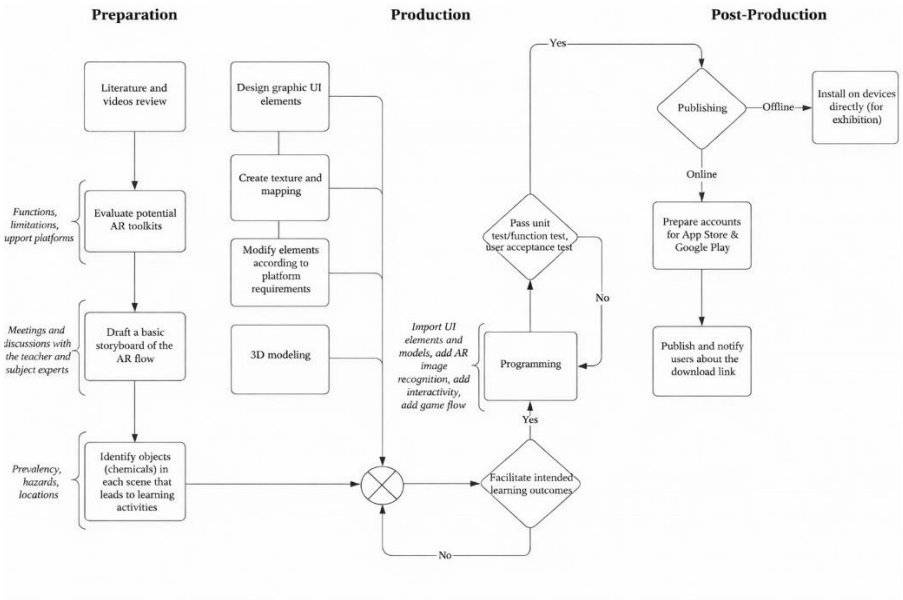

Fig. 2 Flowchart of augmented e-module reality.

Figure 3 displays the use of interactive barcodes connected to various digital platforms and AR-based displays. The product developed in the TDBA-RADEC-based AR E-Module is designed to improve students' environmental literacy. It is structured using the TdBA approach, emphasizing local wisdom in learning practices, and is combined with the RADEC model, which emphasizes active student involvement. The integration of these two models allows students not only to understand environmental concepts theoretically but also to connect them to real life. Thus, students can experience more contextual learning that allows them to observe environmental phenomena more realistically. Figure 4 shows that the use of AR in learning has been proven to increase students' motivation, engagement, and conceptual understanding because it provides a more interactive visual experience compared to conventional media [18, 19]. In Fig. 5, the use of AR-based

E-Modules is expected to encourage students to develop environmental literacy. The integration of digital technology in science and environmental learning can strengthen conceptual understanding while fostering ecological awareness [11, 20].

Fig. 3. Augmented E-module Product Reality Barcode display on the module.

A total of 30 students in the experimental group received learning treatment using RADEC-based Tdba based on school environmental media, while the control group followed conventional learning. Based on the results of the study, there was a significant increase in environmental literacy scores in the experimental group compared to the control group. The increase in scores of 21.8 in the experimental group indicates that the implementation of RADEC-based TdBA based on AR Emodule had a positive influence on students' environmental literacy. In addition, there was a significant difference in environmental literacy scores between the experimental and control groups. After the learning treatment, the post-test results showed an increase in environmental literacy scores in both groups. The difference in increase of 21.8 points reflects a strong positive influence on students' environmental literacy. Finally, this study adds new information regarding sustainable development goals (SDGs) as reported elsewhere [21-25].

Fig. 4. Augmented display reality on the background of students' cell phones.

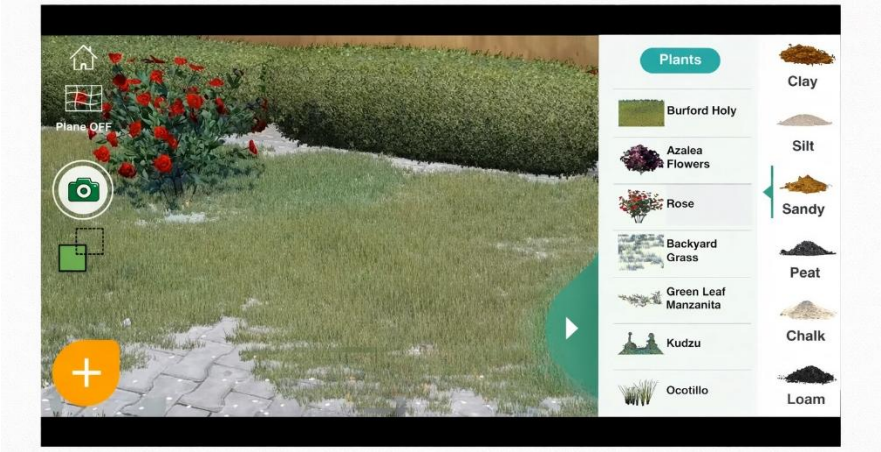

Fig. 5. Application of augmented reality on the school yard with the TdBA pattern.

5. Conclusions

The study found that the implementation of TdBA-RADEC-based e-module learning was effective in improving elementary school students' environmental literacy. This difference in achievement indicates that TdBA-RADEC-based AR e-module learning is more capable of fostering students' understanding, awareness, and practical skills related to environmental issues than conventional learning.

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