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The Effect of Using ARV-Based BILE at Elementary School to Enhance Students' Environmental Understanding

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Abstract

Understanding the environment is an important aspect among elementary school students that should be developed through effective learning using appropriate media, such as the Augmented Reality (AR) that integrates video and information. This study examined the effect of using augmented reality on students' environmental understanding and their improvement on conceptual comprehension. In this quasi-experimental study, a one-group pretest-posttest framework was employed to assess the level of students' understanding. Student's conceptual understanding was measured by science subject test with the topic was 'living environment'. The data of this study were analyzed using Paired Sample T-Test, which results indicated a significant increase in students' conceptual understanding about environmental topics taught by implementing augmented reality. The direct visualization experiences provided in the media allowed elementary school students to enhance their understanding of real-world environmental conditions and awareness of both the impacts and potentials about their surrounding environment.

Keywords: *Augmented reality, living environment, conceptual understanding*

INTRODUCTION

Conceptual understanding is a critical component of environmental education for students, particularly at the elementary level. Mastery of environmental concepts for elementary school students serves as a foundational skill in maintaining and preserving environmental quality (Sandifer et al., 2015; Si et al., 2022). As future generation, elementary students need to develop strong comprehension and compassion to the preservation of the environment (Nugraha et al., 2022; Pulimeno et al., 2020). Unfortunately, students often struggle with understanding the concepts of

the environment, preventing them from having strong sense toward the environment (Villarreal Arroyo et al., 2023), recognizing the environmental potentials (Nurhidayati et al., 2022), and assessing various environmental impacts in their surrounding environment (Norris & Juliet, 2016; Quijano et al., 2023).

The development of conceptual comprehension is a lengthy process that involves experiential learning to allow students directly engaged with their surrounding environment (Ardoin et al., 2020; Goldman & Alkaher, 2023). Fang et al., (2023) stated that suboptimal implementation of this process can disrupt the learning of subsequent topics. Therefore, appropriate teaching strategies should be carefully used (Gajić et al., 2021; Ristanto et al., 2022) in order to keep the students engaged with contextual learning experiences (Soergel & Miller, 2021; Fernández & Espinoza, 2022).

It is challenging of fostering a strong conceptual understanding of environmental issues among elementary school students. Despite the importance of environmental education in shaping students' awareness and responsibility toward their surroundings, many students struggle to grasp environmental concepts effectively. Traditional teaching methods often fail to provide contextual, interactive, and engaging learning experiences, limiting students' ability to comprehend and apply these concepts in real-world situations.

Environmental learning should be facilitated through direct experiential engagement, where students interact with real environmental conditions, potentials, and issues. The contextual approach enhances students' comprehension of the concepts (Hendrickson, 2023; Tessema et al., 2024). Direct experiences can be obtained through on-site observation (Kapici & Coştu, 2023; Kibga et al., 2021) or using simulations (Mitarlis et al., 2023; Zhang et al., 2022). While direct observation of environmental conditions, potentials, and impacts requires considerable time, simulations using various platforms offer an efficient alternative Bulkani et al., (2022) and Permana et al., (2024). The advancement of technology and media used in the simulations allow for accurate replica of the real-world conditions, potentials, and impacts ((Chukwuere, 2020). In the context of this study, the Augmented Reality Video (ARV) is deemed effective for environmental learning.

In addition to the reliability, the media used in the simulation should be adjusted to align with the characteristics of the material and the students' needs. This alignment requires further development, which involves assessing the suitability of media to meet specific educational needs (Saenboonsong & Poonsawad, 2024).

Prasetyo et al. (2020) and Eminita et al. (2024) highlight that the needs analysis process in the study and development is crucial in ensuring that the selected tools effectively support learning objectives (Jibril & Çakir, 2023). Augmented Reality Video (ARV) has been regarded suitable to fulfill students' needs from the video integration (Muangmool et al., 2023) and the interactive presentation of various information about the environment (Li et al., 2020). Sarıgöz, (2019) explained that Augmented Reality (AR) is an advanced technology that provides a real-time display of the physical world enhanced with virtual information. ARV is interactive as it merges real-world objects with virtual data to create dynamic learning experience (Fatimah et al., 2019).

Several studies have reported the benefits of using Augmented Reality Video (ARV), including promoting students' positive responses and behaviors, enhancing conceptual understanding, and enabling the integration of related information or materials. Aldossari & Alsuhaibani, (2021) found augmented reality as a learning medium which fostered students' positive responses and behaviors. Similarly, Düzyol et al., (2022) found that AR in educational settings attracted students' attention more effectively than traditional two-dimensional visual media, as it provided a more realistic experience. These positive learning responses and behaviors supported the students in acquiring the conceptual understanding of the materials. Gu et al., (2022) emphasized that student satisfaction with AR was a key factor in shaping effective learning conditions for more effective knowledge acquisition. Furthermore, AR strengthened knowledge construction by integrating relevant information and teaching materials (Yildiz, 2022). The inclusion of barcodes in ARV aids students in accessing and understanding concepts more comprehensively.

Integrating barcodes into ARV creates a flexible and accessible learning environment, termed the Barcode Integrated Learning Environment (BILE) based on Augmented Reality Video (ARV). Barcodes simplify access to learning materials, allowing students to explore various contents regardless of their whereabouts (Büyükkol Köse & Çetin, 2024; Normawati et al., 2022). Söğüt and Atasever (2024), believe that this integration allows students to engage with videos and material descriptions simultaneously for enhanced learning experience. The integration of augmented reality and supplementary materials is expected to address the gaps in content adequacy (Ozcakir & Cakiroglu, 2021). In this study, ARV-based BILE was developed to create more effective and efficient environmental learning through unique learning experience that enhances student comprehension.

While some previous studies were already conducted focusing on the students' conceptual understanding when ARV was implemented, the impact of ARV-based BILE

on enhancing conceptual understanding has not been explored. This study gained the data to evaluate the effects of ARV-based BILE on the conceptual understanding about environment among elementary school students. ARV-based BILE is expected to simplify the learning process and allow for easier comprehension. Developing a solid understanding of environmental concepts is crucial for fostering students' awareness and concern for their surroundings (Wibowo et al., 2024).

METHODS

This quasi-experimental study was performed using one-group pre-test post-test approach (Creswell & Creswell, 2018) to evaluate the effects of the use ARV-based BILE media on students' conceptual understanding about environmental topic, and to observe the improvement of their conceptual understanding. The design of this study was outlined in Table 1.

Table 1. One Group Pre-test-Post-test

Pretest	Treatment	Posttest
O_1	X	O_2

Source: Creswell & Creswell, 2018

Description:
O_1 : Test before using ARV-based BILE
O_2 : Test after using ARV-based BILE
X : Learning using ARV-based BILE

The population of this study was all students at elementary school Bunulrejo 1 Malang, while the research sample in this study were 18 students selected using random sampling technique. Participants or research sample was selected randomly since the overall population had comparable abilities as shown in their learning outcomes.

The ARV-based BILE media utilized in this study was specifically developed for educational purposes by Sugiri et al. (2023). The development process followed the ASSURE model outlined by Heinich et al. (2001), which has involved the following stages: (1) analyzing learners, (2) stating objectives, (3) selecting methods, media, and materials, (4) utilizing media and materials, (5) requiring learner participation, and (6) evaluating and revising. The ARV-based BILE created through this model has undergone validation and has been deemed valid (Sugiri et al., 2023).

To evaluate students' understanding and improvement on conceptual comprehension, an instrument (students comprehension test) was utilized. This instrument was developed based on the learning objectives about the environmental material, focusing on three key aspects: knowledge, psychomotor, and attitudes. The knowledge aspect assessed the concepts related to living things, ecosystems, and the

environment. The psychomotor aspect evaluated students' activities and actions within school and community settings, while the attitude aspect examined students' behavior towards the environment in both school and residential contexts. The ARV-based BILE media was integrated into the learning process to assess its impact on students' comprehension about the environmental concepts.

The research procedure was carried out systematically to ensure accurate evaluation of the ARV-based BILE media's effectiveness in enhancing students' conceptual understanding about the environmental topics. The first phase, The ARV-based BILE media was developed and validated following the ASSURE model outlined by Heinich et al. (2001), ensuring its suitability for instructional purposes. Additionally, a student comprehension test was prepared to measure knowledge, psychomotor, and attitudes relevant to the environmental topic. In the next phase, a pre-test (O1) was administered to the participants to assess their baseline understanding of the environment. This was followed by the implementation of the treatment (X), where students engaged in learning sessions integrated with the ARV-based BILE media. The activities during this phase were designed to enhance students' understanding of the key environmental concepts, such as living things, ecosystems, and their interactions. After the treatment, a post-test (O2) was conducted to evaluate students' improvements on their conceptual understanding.

The students' conceptual understanding was categorized into three levels: low, moderate, and high. Students scoring less than 70 were classified as having low conceptual understanding. Scores between 70 and 85 were categorized as moderate, while scores ranging from 85 to 100 indicated a high level of conceptual understanding. The data of students' understanding were classified and examined in the paired sample t-test to compare the differences understanding before and after the implementation of ARV-based BILE media (Gerald, 2018). The changes in learning outcomes showed the progress and improvements on students' conceptual understanding following the intervention

RESULTS AND DISCUSSION

Students' initial understanding about the environmental concepts was relatively low as presented in Table 2.

Table 2. Students' Conceptual Understanding of the Environment.

No	Category	Before Treatment (%)	After Treatment (%)
1	Low	61.1	11.1
2	Moderate	38.9	38.9

3	High	50.0

Table 2 compared students' understanding before and after the use of ARV-based BILE. The majority of students (61.1%) had poor conceptual understanding before the intervention, with 38.9% in the medium category and none achieving high category. After the implementation of ARV-based BILE, a significant improvement was identified, where only 11.1% of students remained in the low category, 38.9% were in the medium category, and 50.0% were categorized of having high conceptual understanding. Initial observations of students revealed diverse learning styles and preferences for engaging, and enjoying the learning experiences. Students demonstrated good technological acceptance as shown by their proficiency with various electronic devices such as cell phones, laptops, televisions, and computers.

The learning activities were commenced with the teacher's explanation about the environmental material, and instructions for using the ARV-based BILE media. The explanation provided students with an overview of the content and the learning objectives. Students were given the guidelines on how to use the media for easier navigation of the ARV-based BILE media. The teacher also demonstrated how to use the media in front of the students, offering hands-on practice to ensure that students could effectively engage with the learning tool, shown in Figure 1 and 2. The contents of ARV-based BILE media shown in Figure 3.

Figure 1. The teacher was delivering the explanation of the Learning Materials

Figure 2. The teacher was explaining the guidelines of the use of ARV-Based BILE

Figure 3. The content of ARV-Based BILE

Students were provided opportunities to engage in Q&A sessions and discussions related to the material and the instructions for using the ARV-based BILE media. After the Q&A session and discussion, students participated in group-based learning activities utilizing ARV-based BILE. During these activities, students worked collaboratively in group discussions about the environmental material using the media. In addition to peer discussions, students were also encouraged to ask questions directly to the teacher if there were any aspects of the material, they still found unclear.

Figure 4. Students were using ARV-Based BILE in learning activities.

The discussions and Q&A sessions with their peers facilitated the construction about the concepts being explored. The discussion also engaged students in active construction and internalization of various concepts, which were then presented to their classmates and the teacher. The teacher provided feedback on the students' understanding to refine and evaluate the constructed concepts, shown in Figure 4.

Students preferred learning using gadgets as they could enjoy the engaging experiences from the technology-based learning models. They were particularly interested in learning the materials presented through videos, animations, and interactive games. This enthusiasm became an opportunity for teachers to create innovative lessons using tools such as Quizizz, Canva, and Wordwall. The students' tech skills enhanced their comfort and effectiveness in learning, supporting the achievement of learning objectives.

The study found that using ARV-based BILE media led to a significant improvement in student performance, with average scores increasing from 50.6 to 75.3. The t-test resulted in p (0,001) < □ (0,05), signifying a substantial enhancement in

students' understanding about the environmental material after using ARV-based BILE as shown in Table 3.

		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Understanding	Equal variances assumed	6.265	34	.001	24.667	3.937	16.665	32.668

The results of the study indicated that ARV-based BILE media significantly enhanced students' understanding about the environmental concepts. This finding aligned with the study of Kazanidis et al. (2021), which highlighted that augmented reality (AR) made a substantial contribution to knowledge construction in learning. According to Kazanidis et al. (2021), AR supported the explanation and concretization of real-world application design elements, and enhancing students' comprehension. BILE served as a complementary tool that enhanced ARV by providing detailed explanations and contextual information, particularly through barcodes integrated within ARV, which facilitated deeper engagement with environmental concepts.

Pujiastuti & Haryadi, (2020) found that augmented reality (AR) significantly improved students' understanding of food security concepts, where 50 students in both an experimental and a control group, showed higher gains in the group using AR, highlighting its effectiveness in providing real-world visualizations. Sudarma et al., (2024) also noted that visual experiences and contextual explanations could enhance learning outcomes. Woods (2024) highlighted that visual experience led to better understanding when used in combination with clear and organized information. BILE played a key role in enhancing AR by adding context and explanations to the visuals that the students could see. The integration of BILE and ARV created a comprehensive learning tool that effectively improved students' understanding about the concepts they learned.

ARV-based BILE media was designed to meet the specific needs of both students and the material being studied. Its development involved a thorough analysis of student requirements, learning goals, and the creation of relevant materials and evaluation methods. Understanding student characteristics became essential for determining the most effective media format. Learning media tailored to both the content and the learners enhanced students' understanding (Hiranyachattada & Kusirirat, 2020). Furthermore, Tatarnikova et al., (2022) emphasized that effective learning media helped achieve educational goals, which could be measured by

students' grasp of the subject.

Teachers became crucial in creating and using appropriate media and information from learning materials to achieve educational goals. It's important that learning materials aligned with students' characteristics (van Geel et al., 2023) and were effectively integrated into learning media (Isnandar et al., 2023). Combining visual media, information, and suitable teaching methods could significantly enhance students' understanding (Liu et al., 2018). BILE and ARV integrated visual elements, like videos, with informational content in one learning platform.

Study showed that ARV-based BILE significantly improved students' understanding about the environmental concepts as shown in the significant improvement on students' average scores. Statistical analyses of pre- and post-implementation scores revealed significant gains in comprehension. This improvement was linked to the learning media's ability to provide essential visualizations and information. Hidayati et al. (2024) noted that visual representations reflecting real-life events enhanced understanding, offering a more tangible learning experience for environmental concepts (Stanciulescu et al., 2024) and facilitating comprehension (Abdulrahaman et al., 2020). ARV-based BILE was particularly effective due to its comprehensive features, including clear instructions, engaging design, videos, and relevant information that supported environmental learning.

ARV-based BILE provided clear and systematic instructions that allowed for easier use. Marpanaji et al. (2018) highlighted that clear instructions were essential for the smooth use of learning media. These instructions greatly influenced students' ability to navigate and utilize the media effectively (Fatimah et al., 2019). Massey et al. (2022) also pointed out that well-designed instructions could shape students' perceptions of the media, affecting the overall learning process.

The effectiveness of ARV-based BILE in educational contexts was further enhanced by its user-friendly layout and interface (Abdulrahaman et al., 2020). The organization of material was carefully aligned with the content level for systematic knowledge construction. Jee et al. (2022) asserted that the arrangement and design of concepts within learning media should follow a logical sequence that adhered to the nature of knowledge construction (Yves et al., 2023).

The design of the learning media was tailored to students' cognitive levels and aimed to capture their attention. Puspitarini & Hanif (2019) emphasized that materials and videos should align with student characteristics to boost motivation and curiosity (Ho et al., 2021). An engaging design could enhance student interest in the learning

process, with ARV-based BILE ensuring that images, narratives, and text meet educational goals. Effective design elements played a key role in fostering students' interest in learning (Ardiansyah et al., 2024). Rone et al. (2023) also highlighted that increased student interest led to greater engagement and enthusiasm for learning, which were vital for a positive educational experience.

ARV-based BILE was also enhanced by high-quality video content related to environmental topics. Good video quality increased students' comfort and engagement (Sen, 2022). Alp Christ et al. (2024) noted that quality videos could spark students' interest and encouraged deeper exploration of concepts. The relationship between motivation, interest, and video quality significantly impacted students' understanding levels (Lena et al., 2022). When high-quality videos paired with relevant materials, they enhanced the potential for comprehensive knowledge construction among students.

Students could access the videos and materials in ARV-based BILE regardless of time and place. This media could be used both at school and at home, allowing for flexible engagement whenever students chose. The mobility and flexibility of ARV-based BILE enhanced access to educational content, enriching the learning experience. Such convenience could boost enthusiasm for learning (Caratiquit & Caratiquit, 2023), improved learning outcomes (Hussein & Hilmi, 2021), and enhanced conceptual understanding (Haleem et al., 2022). Overall, the adaptability of ARV-based BILE provided a unique approach to environmental education.

ARV-based BILE encouraged students to investigate their surroundings, fostering curiosity, which was vital for environmental learning and developing a scientific attitude (Jirout, 2020; Weible & Zimmerman, 2016). This scientific mindset helped students think logically and systematically aiding knowledge construction (Şaşmaz-Ören et al., 2022; Suratmi & Sopandi, 2022). The combination of knowledge from ARV-based BILE and real-world observations enabled deeper understanding of environmental concepts. ARV-based BILE allowed for simulations that enabled students to make predictions, further enriching their learning experience.

Simulations in environmental learning through ARV-based BILE also allowed students to analyze and predict phenomena in their surroundings. This predictive analysis helped them understanding environmental potential and impacts, enhancing their comprehension of their ecological context (Wibowo et al., 2024). Such knowledge was essential for promoting proactive behaviors (van de Wetering et al., 2022) and fostering positive attitudes (Faize & Akhtar, 2020) toward the environment. These positive actions and attitudes ultimately contributed to develop individual

environmental awareness (Bøhlerengen & Wiium, 2022).

Promoting positive actions and attitudes is crucial for ensuring the sustainability of environmental quality in the future. Guiding elementary school students to adopt constructive behaviors toward their environment becomes essential, as they are the next generation responsible for safeguarding ecological integrity (Yavuz Tabak et al., 2021). Therefore, instilling a strong understanding of environmental concepts to these students is vital. Those who grasp these concepts well are better equipped to anticipate future environmental conditions (Hao, 2022; Villarreal Arroyo et al., 2023). This predictive ability helps them identify impacts that need to be mitigated and opportunities that can be harnessed sustainably

CONCLUSION

ARV-based BILE significantly enhanced conceptual understanding by offering elementary school students direct visual experiences of environmental conditions and potentials. This simulation allowed students to observe and engage with the material, facilitating a clearer comprehension of environmental concepts. This understanding became crucial for fostering a sense of responsibility and awareness for their surroundings. This study had several limitations that should be considered. First, the research subjects were limited to a single class of 18 elementary school students from Bunulrejo 1 Malang, making the findings less generalizable to a broader population with diverse academic or socio-cultural backgrounds. Second, the content developed in the ARV-based BILE media focused exclusively on environmental topics, limiting its applicability to other subjects or learning areas. Therefore, future research involving more diverse participants and a wider range of learning materials is necessary to gain a more comprehensive understanding of the potential of ARV-based BILE in various educational contexts.

Future research is encouraged to explore the effect of using ARV-based BILE on the development of 21st-century skills and students' environmental awareness. This investigation has provided insights on how these educational approaches have contributed to academic understanding and proactive environmental awareness of the students.

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