DEVELOPMENT OF INTERACTIVE CONTENT IN WEBSITE LEARNING MEDIA TO ADDRESS STUDENT MISCONCEPTIONS ABOUT THE GREENHOUSE EFFECT

Syva Lestiyani Dewi¹, Dede Trie Kurniawan¹, Rendi Restiana Sukardi¹
¹Universitas Pendidikan Indonesia Kampus Cibiru
Email: syva_ld@upi.edu

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Abstract
This study addresses the pressing need to improve students’ comprehension of the greenhouse effect by leveraging innovative website-based Augmented Reality (AR) learning media. The purpose is to explore the effectiveness of this media in mitigating misconceptions surrounding the greenhouse effect while providing practical solutions for educators. The research methodology combines qualitative Design and Development (D&D) approaches with quantitative measures to comprehensively evaluate the impact of AR learning media on students’ understanding. Results demonstrate a significant increase of over 50% in student comprehension post-media use, validated by expert assessments and positive teacher feedback. Students reported overcoming prior misconceptions through the media’s interactive approach. The study emphasizes the necessity of identifying key elements for effective AR learning, recommending comprehensive teacher training, content updates, and long-term impact assessments. The holistic approach employed unveils insights into how learning media can effectively reduce misconceptions, thereby enhancing awareness of crucial environmental issues like the greenhouse effect.

Keywords: Augmented Reality, Elementary School, Greenhouse Effect, Misconceptions, Website

INTRODUCTION
The greenhouse effect is a complex scientific concept that is often misunderstood, even by elementary school students. Misconceptions about the greenhouse effect can lead to a lack of understanding about climate change and its impact on the environment (Bai et al., 2023; Hakim et al., 2022; Wang, 2022). Therefore, it is necessary to develop effective learning media that can help students understand the greenhouse effect and its implications.

The media is seen to be helpful for teaching in the classroom since it improves comprehension and memory as well as the possibility of showing pupils examples, specimens, and
Illustrative situations (Kismunthofiah, 2023). In recent years, augmented reality (AR) has emerged as a promising tool for science education. AR-based learning media combines video, special effects, and AR to provide students with new and exciting visual, auditory, and tactile experiences (Fraga-Lamas et al., 2021; Huguet et al., 2022; Lo et al., 2021; Sulistyowati et al., 2021). This approach has been proven effective in helping students understand complex scientific concepts, including the greenhouse effect. By using AR-based learning media, students can explore the greenhouse effect in a more interactive and engaging way, which can help overcome misconceptions and improve learning outcomes.

The creation of website learning media with AR is motivated by the fact that elementary school students often have misconceptions about the greenhouse effect, which can lead to a lack of understanding about climate change and its impact on the environment. For example, students may believe that the greenhouse effect is caused by the glass in the greenhouse or that the greenhouse effect is a bad thing that needs to be eliminated. These misconceptions may be difficult to overcome, but AR-based learning media has proven effective in helping students understand the greenhouse effect and its implications (Atasoy et al., 2020; Bai et al., 2023; Ewim et al., 2023; Sabra & Al-Moaz, 2022).

Given the urgency of addressing climate change and the importance of educating future generations about its impacts, there is an urgent need to develop effective learning media that can help students understand the greenhouse effect well (Cho & Park, 2023). Several scientific studies have been conducted on the effectiveness of learning media in reducing misconceptions about the greenhouse effect among students. For example, a study conducted in Turkey aimed to determine the level of misconceptions of primary and secondary school students regarding the greenhouse effect (Gul, 2011). Another study investigated the effectiveness of including corrective information related to well-documented misconceptions about the greenhouse effect and how climate works (McCuin et al., 2014). Besides, a study found that the use of interactive technologies, such as virtual experiments, can support students' understanding of the greenhouse effect and global warming (Varma & Linn, 2012). These studies provide valuable insights into the effectiveness of learning media in reducing misconceptions about the greenhouse effect and can help inform the development of effective learning tools.

The utilization of AR-based learning media is an emerging strategy in science education (Fuada & Pradeka, 2022). Creating a website employing this technology to impart knowledge about the greenhouse effect stands as an innovative and unexplored method, potentially fostering greater student engagement and enhancing learning outcomes (Fauville et al., 2020; Lo et al., 2021; ). The use of learning media applications has made the learning experience more interactive, simple to use, and allows the application of learning media applications to improve the quality of teaching that is interesting and easy to understand (Yusa, 2023). By using AR-based learning media, students can
explore the greenhouse effect in a more interactive and engaging way, which can help overcome misconceptions and improve learning outcomes.

METHODS

The background of this study uses a bibliometric analysis approach to see the latest innovations and discoveries in scientific research (Sukaesih et al., 2022). The use of web-based Augmented Reality (AR) media as a tool to reduce student misconceptions related to the concept of the greenhouse effect is still rarely explored in academic literature, thus creating a high element of novelty in this study.

This research generally tends to adopt a qualitative research approach, known as Design and Development (D&D) (Karoror & Jalmo, 2022). This approach places emphasis on developing innovative solutions to address existing practical problems (Aditya, 2018). However, this research also includes a significant quantitative element in the form of measuring the effectiveness of learning media on reducing students' misconceptions about the greenhouse effect.

In the context of D&D, various research methods are used to achieve research objectives. In accordance with Table 1 provided, the researcher chose to adopt type 2 development, referred to as the validation model. This approach involves several research methodologies, including experimentation, in-depth interviews, expert review, and replication (Sulsilah et al., 2023). By using these various methodologies, the researcher sought to gain a comprehensive understanding of the effect of learning media on students' understanding of the greenhouse effect.

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As such, this research reflects a holistic approach, combining qualitative and quantitative elements to explore problems and provide practical solutions in the context of learning about the greenhouse effect. This approach can provide deep insights into how learning media can effectively reduce students' misconceptions, which in turn can improve their understanding of important environmental issues such as the greenhouse effect.

Procedure

The study's approach draws upon a constructivist framework, emphasizing student-centered learning. This pedagogical perspective, rooted in theories like Piaget's constructivism (1970), underpins the methodology involving pre- and post-tests. The pre-test aims to
gauge students' initial comprehension and misconceptions about the greenhouse effect through a mix of multiple-choice and open-ended questions. Subsequently, students will engage with bespoke AR-based learning media tailored explicitly to address these identified misconceptions. Following exposure to this media, a post-test, mirroring the pre-test, will assess changes in students' understanding and any shifts in misconceptions. This sequential approach, common in educational evaluations (Creswell & Creswell, 2017), aligns with constructivist principles by emphasizing active learning and knowledge construction.

Sample
The sample was taken using purposive sampling technique in class IV of SDN Rawa I with 22 students. The selection of the purposive sampling technique in this study aligns with its ability to tailor sample selection according to specific characteristics or research objectives, optimizing time and resources (Palinkas et al., 2015). This method offers the advantage of exploring rare cases or unique contexts while allowing in-depth exploration within the chosen criteria. Its inherent flexibility contributes to the research's validity by honing in on specific attributes of interest. However, it's crucial to acknowledge the potential for selection bias associated with this technique and address it diligently in the study design.

Instrument
The use of multiple questionnaires in this research aligns with the principles of data collection diversification, emphasizing the perspectives of media experts, teachers, and students. This approach resonates with the Triangulation Theory, which posits that utilizing multiple data sources and methods strengthens the overall validity of the research findings by corroborating diverse viewpoints.

The media expert validation questionnaire sheet is used to evaluate the suitability and effectiveness of the website-based AR learning media in addressing greenhouse effect concepts. Teacher response questionnaire sheet is used to get teachers' perspectives on the experience of using AR learning media in their teaching. The student response questionnaire sheet collects data from students who take part in learning by using website-based AR media. This questionnaire will show whether students' misconceptions are reduced after using this media. The pretest and posttest instruments are also used in this study to measure changes in students' understanding before and after using the website-based AR learning media. With the combination of these instruments, this study aims to provide a comprehensive understanding of the effectiveness of learning media in overcoming students' misconceptions about the greenhouse effect.

Data Analysis
The Rasch model employed in this study aligns with the Item Response Theory (IRT), specifically the Rasch measurement theory. The Rasch model within IRT assesses how well items (questions in pretest and posttest) measure an underlying trait or construct (students' understanding of the greenhouse effect) along a
unidimensional scale (Bond & Fox, 2015). This model is used to measure students' level of understanding of the concepts related to the greenhouse effect in more depth. By applying the RASCH model, this study can produce a more detailed understanding of the changes in students' understanding before and after intervention with website-based AR learning media. RASCH model provides a strong analytical framework to objectively measure students' progress, which will help in evaluating the effectiveness of learning media in reducing students' misconceptions (Manik et al., 2022).

RESULTS AND DISCUSSION

Web-based Augmented Reality Learning Media

In this increasingly digitally connected era, education has undergone major changes in teaching and learning approaches. One of the important developments in education is the use of Augmented Reality (AR) technology as an innovative and effective learning tool (Choi & Kim, 2020; Dagnaw & Tsigie, 2021; Partiwi, 2019). The greenhouse effect stands as a critical and urgent environmental concern, pivotal for the knowledge base of forthcoming generations (IPCC, 2021). By combining elements of AR technology, attractive design, and informative content, this media has the potential to be an effective tool in helping students understand this complex concept (Bangay & McKenzie, 2022).

This web-based AR learning media has been designed with great care and dedication to be an interactive, informative and effective tool in helping students and teachers understand the concept of the greenhouse effect better. In this context, the greenhouse effect refers to the understanding of what it is, including its causes, effects, and countermeasures. With a web-based approach, this effort aims to provide maximum accessibility so that students and teachers can easily access relevant information, opening the door to a deeper understanding of the crucial issue of climate change.

In terms of visual design, this website has paid attention to the selection of attractive and aesthetic colors, with the aim of creating a fun and interesting learning environment for users. The fonts used are designed to be easy to read by students, avoiding visual barriers that might interfere with the learning process. The language used in this website has also been carefully selected, with the aim of being easily understood by students of all ages. Technical terms that may be complex are replaced with clear explanations and simpler language, allowing students to access the material without linguistic barriers. Utilizing a variety of media and learning resources not only increases student motivation, but also enriches the presentation of learning (Sutisna et al, 2021).

The website-based AR media integrates various interactive features, each serving a specific purpose aimed at enhancing students' comprehension of the greenhouse effect. Embracing Constructivist Learning Theory (Piaget, 1970; Vygotsky, 1978), these features such as animations depicting the greenhouse effect process, concept-visualizing diagrams, and real-life
illustrations actively engage students in the learning process. Designed as cognitive tools within Vygotsky's Zone of Proximal Development, these features are instrumental in fostering a deeper understanding of climate change triggered by the greenhouse effect. Beyond being a mere educational tool, this AR-based platform serves as a knowledge window, rectifying misconceptions, elucidating climate change implications, and piquing students' interest in vital global environmental issues. Here are some visualizations of the AR website.

Figure 1. Display of one of the QR codes that students can scan so that it brings up AR

Figure 2. Simulation view using Phet Colorado

Figure 3. Features for taking student responses (Google Forms & Padlet)
Recent studies conducted by Johnson (2021) and Chen & Wang (2022) corroborate the efficacy of website-based AR learning media in improving student comprehension of complex concepts, aligning with the findings of this study. Johnson (2021) highlighted the positive impact of AR technology on student engagement and learning in science education, while Chen & Wang (2022) specifically explored the effectiveness of AR-based platforms in conveying environmental concepts, akin to the positive validation received from media experts in this research. Furthermore, insights from Lee et al. (2023) meta-analysis emphasize the pivotal role of engagement tools for teachers, echoing the observations made by educators in this study regarding the AR media's dual effectiveness in content delivery and student engagement. The questionnaire results from students who actively use this learning media illustrate a high level of satisfaction and a positive perception of their ability to use the learning media helped them understand the concepts of the greenhouse effect.

Students felt that this media overcame any misconceptions that may have existed previously and significantly improved their understanding. In addition to the questionnaire, student test results involving a comparison between pretest and posttest also provide strong evidence that the use of this web-based AR learning media is able to reduce students’ misconceptions and significantly improve their understanding of the greenhouse effect. With these evidences, it can be said that the web-based AR learning media is a very feasible and effective learning resource in helping students better understand the complex concepts of the greenhouse effect. In this regard, ongoing efforts to update and improve the content as well as support for educators will continue to be necessary for this medium to remain effective and relevant in supporting students' understanding of climate change and other environmental challenges.

In addition, this web-based AR learning media is not only provides conceptual understanding, but can also motivate students to participate more actively in learning, stimulate their...
interest in environmental issues, and provide a solid foundation for a sustainable understanding of climate change in the future (Bisht & Meera, 2023; Fraga-Lamas et al., 2021; Lo et al., 2021). In the changing context of education, the use of AR technology like this has great potential in improving the quality of learning and enhancing students' understanding of pressing global issues such as the greenhouse effect.

**The Effect of Website-Based AR Media on Student Misconceptions**

The results of analyzing students' pretest and posttest data show a very significant effect of using website-based Augmented Reality (AR) learning media in reducing students' misconceptions about the concept of the greenhouse effect. Before using AR media (pretest), most students showed inaccurate understanding or even significant misconceptions related to the greenhouse effect. However, after participating in the use of AR media, there was a noticeable decrease in the number of students who still maintained misconceptions on the posttest. The results show that almost more than 50% of students who initially had misconceptions were able to understand the concept of the greenhouse effect better after using this AR media (Figure 5).

![Figure 5. (A) Wright map of student pretest results, (B) Wright map of student posttest results](image)
In addition, the results of the data analysis also showed variations in the level of change in students' understanding. Some students showed drastic changes in their understanding, while some students experienced more moderate changes. This may be influenced by a number of factors, including the level of student interaction with the AR media, the level of difficulty of the material, and individual student factors (Gordon et al., 2021; Mufida et al., 2022). It is important to note that although there are variations in changes in understanding, overall, the web-based AR learning media has had a significant positive impact in reducing students' misconceptions about the greenhouse effect. These findings provide strong support for the use of AR media as an effective learning tool in addressing misconceptions and improving students' understanding of complex concepts.

In the context of developing and evaluating web-based AR learning media to understand the greenhouse effect, discussion is an important stage to evaluate the impact and relevance of this media in education. The results of the questionnaire analysis involving experts, teachers, and students indicated that this media was successful in meeting the set success criteria. The media experts gave a positive validation of the content and technicalities of the media, indicating that the material presented effectively illustrated the concept of the greenhouse effect. Teachers expressed that the media can be used practically in their teaching and help students understand the concept better. The students' questionnaire results, which reflected their perceptions of the learning media, also showed a high level of satisfaction, and students felt that the media helped them overcome misconceptions that may have existed previously.

Furthermore, the results of the student comprehension test comparing the pretest and posttest indicated a significant increase in students' understanding of the greenhouse effect after the intervention using this media. This suggests that web-based AR media can effectively help students internalize these complex concepts. However, it should be noted that the success of this media in helping students' understanding is also influenced by how teachers integrate this media in the learning process. Therefore, training and support for teachers in using this media may need further attention.

In addition, it should be noted that the development of this web-based AR media is not only about presenting information, but also about motivating students to learn and understand the impact of the greenhouse effect on climate change. The interactive features provided, such as animations and case examples, aim to make learning more engaging and participatory. Therefore, the development of more in-depth and diverse content will enrich students' learning experience. This finding is in line with previous research showing that technology-based learning approaches, particularly AR technology, can help students overcome misconceptions. The interactivity presented by AR media,
the visualization that helps students see the greenhouse effect concretely, and the engagingly designed content all contribute to the effectiveness of this media. These results also support the view that learning through real experiences and visualizations can overcome misconceptions and improve concept understanding.

Further research and more in-depth content development can be the next step to maximize the potential of this website-based AR learning media. The development of richer and more diverse content, covering various aspects of the greenhouse effect, can enrich students' learning experience. In a broader context, this AR media can also be integrated in educational efforts on global climate change, thus making a real contribution in preparing future generations to face increasingly pressing environmental challenges.

The observed potential of web-based AR learning media in enhancing students' comprehension of the greenhouse effect aligns with the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006). This framework emphasizes the integration of technology (AR learning media) with pedagogy (teaching strategies) and content (environmental concepts), showcasing the promising synergy evident in this study's positive outcomes.

CONCLUSIONS AND SUGGESTIONS

The website-based Augmented Reality (AR) learning media developed for understanding the greenhouse effect has shown promising results in improving student comprehension. Its success, validated through positive feedback from experts, teachers, and students, highlights its potential as an effective educational resource. The enhanced learning outcomes serve as robust evidence of its efficacy in elucidating complex environmental concepts.

To further leverage the effectiveness of AR learning media, exploring and pinpointing the specific elements crucial for enhancing student understanding should be a priority. Equipping teachers with comprehensive training is essential to optimize its integration into teaching practices. Maintaining updated and relevant content aligned with evolving environmental issues will ensure the continued impact of this educational tool.

Continued research endeavors should delve into longitudinal studies to assess the sustained impact of AR learning media on students' comprehension of environmental issues like the greenhouse effect over time. Investigating the longitudinal effects will provide invaluable insights into its lasting educational contributions and foster a deeper understanding of its role in shaping students' awareness.

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