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Developing Augmented Reality-Based Learning Media to Overcome Fourth-Grade Elementary School Students' Misconceptions Regarding the Ice Melting Phenomenon

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Abstract
This study aims to create learning media using ice melting materials for the fourth-grade students and test the effectiveness of the learning media in learning science. This research is conducted by Research and Development (R&D) method with ADDIE model. The population studied is the student of the grade IV students in Banyumas Regency Elementary School. The instruments in this study are in the form of expert validation sheets, conceptual understanding tests in the form of pre and posttests, and documentation. The data analysis techniques used were Wilcoxon Signed Rank Test and N-Gain analysis. Based on the research results, the media used in this study is a learning media based on AR can be seen as a media that can increase the conceptual understanding of students in the phenomenon of the melting of ice. The average N-Gain score is 0.77, which represents a significant improvement in learning outcomes and is considered high. The results of these findings indicate that the Augmented Reality based learning media has been developed successfully in reducing student misconceptions and increasing students' understanding of the material submitted.
Keywords: Augmented Reality, misconceptions, melting, ice, phenomenon.

1. Introduction

Melting ice is one of the physical events occurring in everyday life that is often encountered and is one of the fundamental concepts taught in elementary school (Åhman & Niclas, 2020). However, many studies have revealed that students' conceptions of the phenomenon of phase changes are misconceptions. Some students reason that ice will melt if it is exposed to air when it is observed in an open setting. However, the melting process is scientifically caused by the transfer of heat energy from the surrounding environment, with a higher temperature, to the ice, which has a lower temperature (Gerhátová & Perichta, 2021). Such misconceptions may hinder the development of

accurate conceptual understanding and negatively affect students' learning of more advanced scientific concepts in the future.

The problem is that there are errors that can occur during science learning due to various factors, such as the limited application of science learning media and the absence of hands-on learning experiments in science learning (Chen, 2024). Drill-and-practice-type teacher-directed instruction has few opportunities for students to experience meaningful learning. This may make it harder for students to understand scientific concepts in terms of real-world phenomena, leading to an inaccurate understanding of abstract concepts (Herrmann et al., 2025).

Learning media are important in helping students' conceptual understanding. The study by Hidayah (2025) states that learning becomes more effective if students are given concrete experiences first before being introduced to abstract experiences. Based on conceptual change theory, cognitive reconstruction should be carried out when students have misconceptions to ensure that they review their previous conceptions and then change them to new conceptions that are accepted by science (Amiruddin, 2025). Conceptual change theory emphasizes that learning does not only involve adding new information, but also restructuring students' prior knowledge when their existing conceptions are inconsistent with scientific explanations.

The use of learning media with AR is one innovative solution that can facilitate this process. Augmented Reality is a technology that merges 3-D virtual objects with the real world (Dargan & Shally, 2023). In science education, AR can help to visualize abstract concepts and create meaningful learning experiences, which, in turn, helps to build deeper conceptual understanding (Supardi et al., 2015). Previous research has shown that AR-based learning media can support science learning because it provides visual, interactive, and contextual learning experiences. For example, Jamhari and Maarif (2025) developed AR-based media for elementary science learning and found that it improved students' science literacy and engagement. However, studies that specifically develop Assemblr EDU-based AR media to overcome fourth-grade elementary students' misconceptions about the ice melting phenomenon are still limited. Therefore, the novelty of this study lies in the development of Assemblr EDU-based AR media that integrates conceptual change and constructivist learning principles to help students understand ice melting as a heat absorption process.

Assemblr EDU is one of the platforms that has the potential to develop AR based learning media, especially for teachers who want to create and present learning media interactively. This platform was chosen because it allows teachers to design and display 3-D learning objects easily without requiring advanced programming skills.

Students will be able to learn about scientific phenomena through interactive and visual experiences using Assemblr EDU. This technology can make heat transfer processes more tangible and concrete, giving the students not only verbal instructions, but also visual imagery of the actual scientific process of melting ice. These interactive learning experiences can contribute to the improvement of conceptual understanding and elimination of misconceptions (Suparlan, 2018). Constructivist learning theory explains that knowledge is formed from meaningful interactions in learning. AR is suitable for constructivist learning because students can observe, explore, manipulate, discuss, and reconstruct scientific concepts through direct interaction with virtual objects in a real learning environment.

The needs analysis in an elementary school in Banyumas Regency showed that the technological facilities were adequate to support digital learning. However, the limited availability of interactive digital learning media caused these facilities were not optimally used. Moreover, during classroom observations, many misconceptions about the phenomenon of melting ice were observed.

Based on this, the purpose of this research is to find out whether the use of Assemblr EDU can overcome students' misconceptions about the phenomenon of melting ice, to be able to more accurately explain the melting ice phenomenon as a result of heat absorption and to analyze the effectiveness of the medium in facilitating science learning in elementary schools using the constructivist theory.

2. Methods

This research used a Research and Development (R&D) approach using the ADDIE model. The ADDIE model consists of five stages, namely Analysis, Design, Development, Implementation, and Evaluation. This model was chosen because it provides systematic steps for developing learning media, validating the product, revising the product, and testing its effectiveness in the learning process.

The subjects of the study were fourth-graders in elementary schools located in Banyumas District. The trial process was conducted in two stages: a limited trial with 10 students and a large-scale trial with one class. The total number of students who completed both the pretest and posttest was 27 students and these data were used in the final analysis. The implementation stage used a One-Group Pretest-Posttest Design, in which students were given a pretest before using the media and a posttest after the learning intervention.

At the Analysis stage, the researcher analyzed students' needs, learning characteristics, school technological facilities, and students' misconceptions about the ice melting phenomenon through

classroom observation and initial evaluation. At the Design stage, the researcher designed the learning objectives, learning flow, storyboard, learning content, AR object display, navigation, and evaluation instruments. At the Development stage, the researcher developed the AR-based learning media using Assemblr EDU and conducted expert validation involving language, media, and subject matter experts. The media was revised based on expert suggestions before being implemented with students. At the Implementation stage, the media was used in the learning process through limited and large-scale trials. At the Evaluation stage, the researcher evaluated the feasibility of the media and the effectiveness of the media in reducing students' misconceptions.

Expert validation was conducted using validation sheets that assessed language accuracy, language appropriateness, readability, contextual relevance, ease of use, and the feasibility of AR features. The validation results were converted into percentages and interpreted using feasibility categories. The expert comments were used as the basis for revision before the media was implemented in the classroom. The revisions included improving the organization of information, clarifying explanations, improving navigation, increasing readability, and strengthening the AR features.

The learning process was carried out using a constructivist-oriented learning process in one science learning meeting adjusted to the regular elementary school schedule. The stages included apperception, pretest, exploration of AR media, guided observation of the ice melting process, discussion of students' initial ideas, confirmation of the scientific concept of heat absorption, conclusion, and posttest. During the learning process, students used Assemblr EDU-based AR media to observe 3-D visualizations of the melting ice phenomenon and relate the visualization to the scientific explanation.

The instruments used in this study were expert validation sheets, conceptual understanding tests in the form of pretest and posttest, and documentation. The pretest and posttest were designed based on indicators of conceptual understanding related to the ice melting phenomenon, including identifying the melting process, explaining heat absorption, explaining changes in the state of matter, and distinguishing scientific concepts from misconceptions. The same indicators were used before and after the intervention to identify changes in students' understanding.
The data were analyzed descriptively and inferentially. Descriptive analysis consisted of calculating mean scores and the Normalized Gain (N-Gain) index to determine the increase in students' conceptual understanding after using the AR media (Nisa et al., 2025). The N-Gain score was interpreted using three categories: high ($g \geq 0.70$), moderate ($0.30 \leq g < 0.70$), and low ($g < 0.30$). The feasibility percentage was interpreted using the categories presented in Table 1.

The Shapiro-Wilk test was used to test the normality of the pretest and posttest data (Anggoro et al., 2019; Nisa et al., 2025). If the data were normally distributed, the hypothesis would be tested using a paired sample t-test. However, if the data were not normally distributed, the Wilcoxon Signed Rank Test would be used. The hypotheses in this study were H_0: there is no significant difference between students' conceptual understanding before and after using the Assemblr EDU-based AR media; and H_1: there is a significant difference between students' conceptual understanding before and after using the Assemblr EDU-based AR media. The decision criterion was based on the significance value of 0.05.

Table 1. Feasibility Categories

Percentage	Category
85–100%	Highly Feasible
70–84%	Feasible
60–69%	Moderately Feasible
<60%	Not Feasible

3. Result and Discussion

This section presents the results of the development and implementation of Assemblr EDU-based Augmented Reality learning media according to the ADDIE stages. The explanation includes the results of analysis, design, development, implementation, and evaluation, followed by a discussion of the effectiveness of the media in overcoming students' misconceptions about the ice melting phenomenon.

1. Analysis

The analysis stage was carried out to determine the needs, characteristics, and misconceptions of students when studying the phenomenon of ice melting. Through classroom observations and initial evaluations, it was found that students still had difficulty understanding the scientific concepts involved in the melting process. For most of the students, melting was considered only as the disappearance of ice when it is heated, and they did not understand how heat transfer and changes in the state of matter occur. Hence, fourth-grade students require visualization in order to understand the process, and this need was addressed through AR media.

2. Design

In the design stage of the learning media, the structure and layout of the learning media were designed based on learning objectives, curriculum needs, and students' characteristics. The design included storyboards, learning content, user interface, navigation, and evaluation instruments.

The media made in the design stage was quite simple, attractive, and easy to use for elementary school students. The content was directed towards the phenomenon of melting ice, explanations about the phenomenon, factors affecting the melting of ice, and concrete examples from everyday life. Using three-dimensional AR objects, students were able to visualize the process of melting more concretely, which helped them to better grasp the melting process.

3. Development

The learning media was created with the Assemblr EDU platform and was tested by experts. The language expert evaluation gave an 80% feasibility score, suggesting that the language used was appropriate and understandable for elementary school students. The media expert confirmed that the visual and technical aspects supported the learning objectives well, and suggested minor changes to the layout, navigation, and readability.

The feasibility score in the subject matter expert evaluation was 82.5% (which is highly feasible). The expert verified that the content was scientifically accurate, curriculum appropriate, and suitable for fourth-grade students. A few changes were incorporated as a result of expert recommendations, such as better organization of information, clearer explanations, improved navigation, better readability, and stronger AR features before the media was implemented with students.

Table 2. Recapitulation of the Overall Assessment Results

Aspect	Maximum Score	Obtained Score	Percentage	Category
Language Accuracy	20	20	100%	Highly Feasible
Language Appropriateness	20	15	75%	Feasible
Readability	20	15	75%	Feasible
Contextual Relevance	20	15	75%	Feasible
Ease of Use	20	15	75%	Feasible
Feasibility of AR Features	20	15	75%	Feasible
Total	120	95	79.16%	Feasible

The result of the assessment of the learning media was considered feasible based on the results obtained. This finding suggests that the media is suitable for implementation in the learning process and can be used effectively in this research.

Table 3. Development Results of the Augmented Reality Learning Media

No.	Display	Description
1	 Main AR Learning Media Display	Shows the main screen of the Augmented Reality learning media showing the phenomenon of melting ice in the form of a 3D visualization. The page is the main learning environment that students can interact with virtual objects and watch scientific processes in an exciting and realistic way.
2	 Cover Menu Display	Displays the first page of the learning media, the title, theme, and navigating buttons to take students to the other pages of learning.
3	 Introduction Stage Display	The design is attractive which can be used to stimulate students' interest and motivation before entering into the learning activities.
4	 Learning Material Display	Uses Augmented Reality visualisations, explanatory text and animations to present the teaching content. This section allows students to see and experience scientific concepts in a more tangible and meaningful way.

5	 Trigger Question Display	Asks probing questions to elicit students' interest, critical thinking and conceptual thinking. These questions prompt students to make predictions, analyze and explain the process of melting ice using scientific concepts before they engage with the AR visualization.
6	 Conclusion Display	Concise explanations that summarize key concepts that have been learned during the lesson and reinforce students' conceptual understanding. This section encourages student reflection on the material and enhances the conceptual change process.
7		The AR display can be accessed through the Assemblr EDU app. Students can use their mobile devices to scan the bar code and interact directly with the 3D learning objects, taking learning to both the classroom and beyond.

The revisions from the experts were used to improve the final version of the media. The revision process included improving the arrangement of the material, simplifying several sentences to make them more suitable for elementary school students, clarifying the instructions for using the AR display, adjusting the readability of the text, and improving the navigation so that students could use the media more easily during the learning process.

4. Implementation

The implementation stage was conducted through a limited trial with 10 fourth-grade students of an elementary school in Banyumas District and continued with a large-scale trial involving one class. The learning process was carried out using a constructivist-oriented learning model in which

students were encouraged to connect their initial ideas with the scientific explanation presented through AR visualization. The learning process consisted of giving a pretest, introducing the learning objectives, guiding students to access the Assemblr EDU-based AR media, observing the 3-D visualization of the ice melting phenomenon, discussing students' predictions and explanations, confirming the concept of heat absorption and phase change, drawing conclusions, and giving a posttest.

The pretest and posttest instruments were conceptual understanding tests developed based on the indicators of the ice melting material. The indicators included students' ability to explain the meaning of melting, identify heat absorption as the cause of ice melting, explain the change from solid to liquid, and correct misconceptions related to the melting process. To obtain students' initial understanding of the phenomenon of ice melting, a pretest was administered before the use of the AR-based learning media. The mean pretest score in the limited trial was 46, which means that there were still many students who had misconceptions about the concept. After students took the pretest, they conducted learning activities with Assemblr EDU-based AR media. Students engaged with 3-D visualizations and explored the process of melting in an interactive learning environment. A posttest was given following the intervention. The mean posttest score was 96, which represents a large increase in students' conceptual understanding and a decrease in misconceptions.

5. Evaluation

The evaluation stage was conducted to determine the effectiveness of the AR-based learning media in improving students' conceptual understanding and reducing misconceptions. In the limited trial, the N-Gain analysis obtained a score of 0.93, which means that there was a significant increase in students' understanding after using the AR media and this result was classified as High. The Wilcoxon Signed Rank Test also gave a significance value of 0.005, which is less than the significance level of 0.05, further supporting the effectiveness of the media. This finding shows a statistically significant difference between pretest and posttest scores.

The overall results indicate that the media is valid and effective in overcoming students' misconceptions. The media offers a new and interesting learning experience which can be recommended for wider use in elementary science learning as it facilitates conceptual learning for students.

Table 4. Normality Test Results for Pretest and Posttest Data (Try-Out)

Variable	Kolmogorov-Smirnov Statistic	Sig.	Shapiro-Wilk Statistic	Sig.
Pretest	0.320	0.004	0.747	0.003
Posttest	0.482	0.000	0.509	0.000

The significance value from the data of Table 4 was 0.003 for the pretest and 0.000 for the posttest. Both significance values were less than 0.05 and therefore the data collected in the limited trial were not normally distributed. The small number of students (n = 10) and the concentration of the same scores in the posttest scores were factors that affected this non-normal distribution.

Table 5. Wilcoxon Signed Ranks Test Results (Try-Out)

Test Statistics	Value
Z	-2.821
Asymp. Sig. (2-tailed)	0.005

The data were not normally distributed and hence a non-parametric statistical test was used. Therefore, the hypothesis testing was carried out using the Wilcoxon Signed Rank Test instead of the Paired Sample t-Test. The value obtained from the SPSS output was lower than the criterion value of 0.05 and hence the alternative hypothesis was accepted. The results of this study show that there was a statistically significant difference in students' concepts before and after using the Assemblr EDU-based Augmented Reality learning media in studying the ice melting phenomenon.

Table 6. Research Normality Test Results

Variable	Shapiro-Wilk Statistic	df	Sig.
Pretest	0.877	27	0.004
Posttest	0.794	27	0.000

Based on Table 6, the data were not normally distributed and hypothesis testing was conducted using the non-parametric Wilcoxon Signed Rank Test to determine differences in students' conceptual understanding before and after using the media.

Table 7. Research Hypothesis Test Results

Statistic	Value
Z	-4.863
Asymp. Sig. (2-tailed)	0.000

Based on Table 7, the Asymp. Sig. (2-tailed) value was 0.000, which is lower than 0.05. Hence, H_0 was rejected and H_1 was accepted. The AR-based learning media proved effective in overcoming misconceptions on the ice melting phenomenon among fourth-grade students of elementary school.

Table 8. N-Gain Test Results

Variable	N	Minimum	Maximum	Mean	Std. Deviation
N-Gain	27	0.500	1.000	0.77469	0.20125

The N-Gain analysis showed an average score of 0.77469 and is in the High category. Hence, the Augmented Reality-based learning media developed in this study was effective in decreasing the number of misconceptions held by fourth-grade elementary students about the phenomenon of melting ice and showed a significant increase in students' conceptual understanding.

4. Discussion

The AR-based learning media created with the Assemblr EDU platform was effective in reducing misconceptions about the phenomenon of melting ice among fourth-grade elementary school students in this research. In the main study, with 27 students, the average N-Gain value was 0.77, which was within the High category. The results of this study indicate that AR media has the potential to help students understand the concept of phase change more concretely by providing interactive 3-D images, which, in turn, reduces students' misconceptions about the concept of phase change.

The results of the main study showed that the normality test produced p-values lower than 0.05, indicating that the data were not normally distributed. Therefore, the Wilcoxon Signed Rank Test was used for hypothesis testing. The analysis resulted in an Asymp. Sig. (2-tailed) value of 0.000, which was statistically significant and indicated a difference between the pretest and posttest. This success is due to the possibility of AR technology allowing students to see and experience the melting process of ice, making it easier for them to understand the process than learning with traditional methods.

This research line is related to the research conducted by Utama (2024), which found that Augmented Reality (AR) has a positive impact on improving students' scientific conceptual understanding and engagement in the learning process. Likewise, Amani (2025) concluded that AR media is effective in enhancing learning outcomes because it can visualize phenomena and objects that are difficult to see directly in the real world. Moreover, Rifai (2025) showed that in elementary science education, it was possible to enhance students' conceptual understanding and eliminate misconceptions by using AR. Similar findings were also reported by Jamhari and Maarif (2025), who developed AR-based elementary science learning media and found that it supported students' science literacy and learning engagement. The results of the present research further evidence the contribution of the developed AR to innovative science learning.

5. Conclusion

This study shows that the media developed using Assemblr EDU platform is valid and can be used in fourth grade elementary students.

The effectiveness of the media was proven with the Wilcoxon Signed Rank Test results and high N-Gain scores obtained, which showed that the students' conceptual understanding improved significantly. By engaging in interactive 3D visualizations, students could gain a more tangible view of science processes, aiding the learning process and conceptual shifts.

Hence, it is recommended that the media be used as an alternative in teaching science in elementary schools, especially when teaching science concepts that are abstract so it is difficult to imagine using conventional teaching techniques.

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