JKTP: Jurnal Kajian Teknologi Pendidikan
Vol. 9, No. 3, August 2026: 385-394
e-ISSN: 2615-8787
DOI: 10.17977/um038v9i32026p385-394
https://journal-fip.um.ac.id/index.php/jktp

THE EFFECT OF ASSEMBLR EDU-BASED AUGMENTED REALITY ON STUDENTS' LEARNING OUTCOMES IN THE WATER CYCLE TOPIC

Mega Rizky Molidina, Susilawati, Dewi Yulianawati
Faculty of Teacher Training and Education, Muhammadiyah University of Cirebon, Cirebon, Indonesia
Corresponding Author E-Mail: megarizkyms19@gmail.com

Article History
Received: 31 July 2026, Accepted: 13 August 2026, ***Published: 16 August 2026***

Abstrak
Penelitian ini dilakukan karena hasil belajar siswa di IPAS (Ilmu Pengetahuan Alam dan Sosial) pada jenjang Pendidikan Dasar, khususnya mengenai siklus air, masih belum optimal. Materi pelajaran yang bersifat abstrak menyebabkan siswa kesulitan dalam memahami konsep-konsep tersebut apabila pengajaran hanya mengandalkan metode konvensional. Tujuan dari penelitian ini adalah untuk menganalisis dampak penggunaan media *augmented reality* berbasis Assemblr Edu terhadap hasil belajar siswa sekolah dasar mengenai siklus air. Pendekatan yang digunakan dalam penelitian ini adalah kuantitatif dengan metode kuasi-eksperimental, menggunakan desain kelompok kontrol yang tidak setara. Sampel terdiri dari kelompok eksperimen yang diajar dengan menggunakan media *augmented reality* berbasis Assemblr Edu dan kelompok kontrol yang diajar dengan bahan ajar konvensional. Data dikumpulkan melalui *pre-test* dan *post-test*, kemudian dianalisis menggunakan uji normalitas, homogenitas, dan uji t sampel independen. Hasil penelitian menunjukkan bahwa penggunaan media *augmented reality* berbasis Assemblr Edu memberikan dampak yang signifikan terhadap hasil belajar siswa. Kelompok eksperimen menunjukkan peningkatan hasil belajar yang lebih besar dibandingkan dengan kelompok kontrol. Oleh karena itu, media augmented reality berbasis Assemblr Edu dapat dijadikan alternatif pembelajaran yang inovatif, menciptakan proses pembelajaran yang lebih interaktif, menarik, dan bermakna, serta memfasilitasi pemahaman siswa terhadap konsep-konsep yang dipelajari.

Kata Kunci: Augmented Reality; Assemblr Edu; hasil belajar; IPAS; siklus air; sekolah dasar

Abstract
This study was conducted because student learning outcomes in IPAS (Natural and Social Sciences) at the elementary school level—particularly regarding the water cycle—remain suboptimal. The abstract nature of the subject matter makes it difficult for students to understand these concepts when instruction relies solely on conventional methods. The purpose of this study is to analyze the impact of using Assemblr Edu-based augmented reality media on elementary school students' learning outcomes regarding the water cycle. This study employed a quantitative approach using a quasi-experimental method with a non-equivalent control group design. The sample consisted of an experimental group taught using Assemblr Edu-based augmented reality media and a control group taught using conventional teaching materials. Data were collected through pre-tests and post-tests, then analyzed using normality and homogeneity tests, as well as an independent samples t-test. The results of the study indicate that the use of Assemblr Edu-based augmented reality media has a significant impact on student learning outcomes. The experimental group demonstrated a greater improvement in learning outcomes compared to the control group. Therefore, Assemblr Edu-based augmented reality media can serve as an innovative learning alternative, creating a more interactive, engaging, and meaningful learning process, and facilitating students' understanding of the concepts being studied.

Keywords*: Augmented Reality; Assemblr Edu; learning outcomes; Science (IPAS); water cycle; elementary school.*

To cite this article:
Molidina, M. R., Susilawati., & Yulianawati., D. (2026). The effect of assemblr edu-based augmented reality on students' learning outcomes in the water cycle topic. *JKTP: Jurnal Kajian Teknologi Pendidikan, 9*(3), 385-394. doi: 10.17977/um038v9i32026p385-394

INTRODUCTION

Natural and Social Sciences (IPAS) is a school subject that plays a crucial role in the development of students' skills, knowledge, attitudes, and to understand the world around them. According to Sumiyati and Surjono (2026), IPAS instruction at the elementary school level is not only intended to promote conceptual understanding but also to develop students' science process skills through observing, investigating, and drawing conclusions from natural phenomena. Similarly, Putri et al. (2020) stated that IPAS provides meaningful learning experiences by engaging students in observing various natural phenomena. This view is supported by Zuwariyah et al. (2021), who explained that scientific knowledge is generated through observation and experimentation. Furthermore, Fuadi et al. (2020) emphasized that IPAS learning aims to foster critical thinking, problem-solving abilities, and scientific skills that students need in their daily lives.

In line with the implementation of the Merdeka Curriculum, IPAS learning is designed to be active, meaningful, and student-centered. Eliya Rochmah et al. (2025) stated that one of the primary objectives of IPAS education is to cultivate students' curiosity about their surrounding environment. Therefore, effective instructional planning, including the appropriate selection of learning media, is essential. Learning media serve as instructional tools that facilitate the delivery of information and help students understand learning materials more effectively (Agustira & Rahmi, 2024). This finding is consistent with Hasan et al. (2021), who argued that instructional media support the communication of learning content during the teaching and learning process. Likewise, Rahman et al. (2023) explained that learning media function as stimuli that enhance students' comprehension of instructional materials. Therefore, selecting appropriate instructional media is considered one of the key factors in improving the effectiveness of IPAS learning.

IPAS learning requires instructional media capable of visualizing abstract concepts to make them easier for students to understand. One topic that frequently presents learning difficulties is the water cycle, as it involves continuous natural processes such as evaporation, condensation, precipitation, and infiltration. According to Yang et al. (2021), the water cycle refers to the continuous movement of water from the Earth's surface to the atmosphere and back again through these processes. Since these processes cannot be directly observed in the classroom, learning that relies solely on verbal explanations or two-dimensional illustrations often fails to provide students with concrete learning experiences. Therefore, the integration of digital technology is necessary to present abstract concepts through more realistic visual representations.

One of the technologies widely adopted in education is Augmented Reality (AR). Resnawati et al. (2023) explained that AR integrates the real world with interactive three-dimensional virtual objects in real time. One platform that utilizes this technology is Assemblr Edu, an application designed to create interactive three-dimensional (3D) and AR-based learning content (Novella et al., 2024). In addition, Assemblr Edu enables three-dimensional objects to be projected into real-world environments through the camera of digital devices, allowing students to observe learning materials more realistically (Sari et al., 2024). This finding is consistent with Susilaningsih et al. (2023), who stated that Augmented Reality combines digital content with the real environment in real time, thereby creating more concrete, engaging, and interactive learning experiences.

Research conducted by Widyanti and Putra (2025) demonstrated that Assemblr Edu-based Augmented Reality media effectively improved elementary school students' learning outcomes in IPAS. Similarly, Wibowo and Putra (2024) reported that Augmented Reality learning media developed using Assemblr Edu for fifth-grade elementary students demonstrated a very high level of feasibility and proved effective for classroom instruction. Lestari et al. (2023) further explained that this application facilitates teachers in developing interactive instructional media, thereby

increasing students' engagement throughout the learning process. With these features, Assemblr Edu has considerable potential as an innovative instructional medium capable of addressing students' difficulties in understanding abstract IPAS concepts, particularly the water cycle. Furthermore, Cahyan (2023) stated that the integration of Assemblr Edu into elementary IPAS instruction enables teachers to present abstract concepts through three-dimensional visualization and Augmented Reality technology, making learning more meaningful and easier for students to comprehend.

The urgency of implementing Augmented Reality (AR)-based instructional media is supported by the learning conditions at SD Negeri 1 Curug Wetan. Based on classroom observations and interviews with fifth-grade teachers, IPAS instruction is still predominantly delivered through lecture-based methods supported only by textbooks and two-dimensional illustrations. As a result, the water cycle concept has not been presented in a concrete and meaningful manner. This condition has contributed to students' low learning outcomes. The daily assessment data show that, out of sixty students, only eighteen have met the criteria for achieving the learning objectives (KKTP), while the remaining forty-two students have not yet reached the expected level of performance. These findings highlight the need for more innovative, interactive, and contextual instructional media to facilitate students' understanding of the concept of the water cycle in a more meaningful way.

The effectiveness of Augmented Reality-based instructional media has been demonstrated in numerous previous studies. Hayati, Sutardjo, and Hanif (2023) reported that the use of Assemblr Edu significantly improved students' learning outcomes in IPAS. Similarly, Handayani and Sami Asih (2024) found that Assemblr Edu-assisted Augmented Reality media enhanced the academic achievement of elementary school students. Furthermore, Akbar (2024) argued that Assemblr Edu is more effective than conventional static media because it provides interactive three-dimensional visualizations that help students understand concepts that are difficult to observe directly, thereby improving their cognitive performance.

According to Aini, Alim, and Firmansyah (2025), elementary school the students are generally in the concrete operational stage of thought according to Piaget's theory of cognitive development. In this stage, understand concepts more effectively when learning involves direct interaction, visual media, or concrete objects that can be observed and manipulated. Consistent with this perspective, Dian Nur Aini (2024) reported that the use of augmented reality-based learning media when teaching the water cycle has a significant positive impact on the learning outcomes of primary school students in science.

Although numerous studies have demonstrated that the use of Augmented Reality and Assemblr Edu can improve students' learning outcomes, research specifically examining the effectiveness of this instructional media in teaching the water cycle at the elementary school level remains limited, particularly in Cirebon Regency. Moreover, previous studies have primarily focused on enhancing students' learning motivation or have been conducted using different subject matter and student characteristics. These conditions indicate that the effectiveness of Assemblr Edu in water cycle instruction requires further investigation through empirical research.

Drawing upon the theoretical framework, findings from previous studies, and preliminary field observations, this study assumes that the implementation of Assemblr Edu-based Augmented Reality instructional media can provide more concrete and interactive learning experiences, thereby improving fifth-grade students' learning outcomes in IPAS. Based on this assumption, the proposed research hypothesis is that the use of Assemblr Edu-based Augmented Reality instructional media has a significant effect on students' learning outcomes in the water cycle topic.

Accordingly, this study aims to analyze the effect of Assemblr Edu-based Augmented Reality instructional media on the IPAS learning outcomes of fifth-grade students in learning the water cycle at SD Negeri 1 Curug Wetan. The findings are expected to contribute to the growing body of knowledge on the integration of digital technology into IPAS instruction and to provide practical guidance for teachers in selecting innovative and effective instructional media to enhance both the quality of the learning process and students' academic achievement.

METHOD

This study employs a quantitative approach using a quasi-experimental method to investigate the impact of Augmented Reality learning media based on Assemblr Edu on students' learning outcomes regarding the "water cycle." The research design used was the Nonequivalent Control Group Design, a quasi-experimental design involving two pre-existing groups without random assignment of participants (Capili & Anastasi, 2025). Both groups completed a placement test to assess the students' baseline competencies, as well as a post-test to measure their learning outcomes following the classroom intervention. The intervention consisting of augmented reality learning materials based on Assemblr Edu was provided exclusively to the experimental group, whereas the control group was taught using traditional learning materials of the type commonly used by teachers in the classroom.The research design is presented in Table 1.

Table 1. Non-equivalent Control Group Design

Groups	Pretest	Treatment	Postest
V b (Experiment)	01	X	02
V a (Control)	03	-	04

In this study, a pretest was administered to both groups to assess the students' initial knowledge and ensure the comparability of their baseline abilities. The experimental group then received instruction using Assemblr Edu-based Augmented Reality media, while the control group was taught through conventional instructional methods. Upon completion of the instructional intervention, both groups were administered a posttest to evaluate their final learning outcomes and to determine the effect of the use of Assemblr Edu-based Augmented Reality media on students' learning outcomes.

The study was conducted at SD Negeri 1 Curug Wetan, Susukan Lebak District, Cirebon Regency, during the second semester of the 2025/2026 academic year. The research population consisted of all 60 fifth-grade students, who were divided into two classes: Class VA and Class VB. A total sampling technique was employed, meaning that all members of the population were included as the research sample. According to Sugiyono (2022), the total sampling method involves selecting the entire population as the sample for the study. Class VB, consisting of 29 students, was designated as the experimental group, while Class VA, with 31 students, served as the control group. This method was chosen because the population is relatively small, allowing for the inclusion of all its members and providing a representative picture of the research context.

The research instruments consisted of a learning achievement test and an observation sheet. The achievement test was used to measure students' cognitive abilities before and after the intervention through the administration of a pretest and a posttest. The test consisted of 20 multiple-choice questions developed based on the learning achievement indicators for the water cycle topic. Before being administered, the instrument underwent tests of validity, reliability, item difficulty, and discrimination index, confirming its suitability for data collection. The observation sheet was used to monitor the implementation of the learning process in both the experimental and control groups, thereby supporting the interpretation of the research findings.

Data collection was conducted in several stages. The first stage involved administering the pretest to both the experimental and control groups to determine students' initial abilities.

Subsequently, the experimental group received instruction using Assemblr Edu-based Augmented Reality learning media, whereas the control group participated in learning activities using the conventional instructional media commonly employed by the classroom teacher. After the instructional sessions had been completed, both groups were administered the posttest using the same instrument to determine changes in students' learning outcomes following the intervention. Throughout the instructional process, the researcher also conducted classroom observations to obtain supporting data for the study.

The data were analyzed using IBM SPSS Statistics version 26. The analysis began with descriptive statistics to summarize the mean, maximum, minimum, and standard deviation of the pre-test and post-test scores. Subsequently, tests of assumptions were conducted, including the Shapiro-Wilk test for normality and Levene's test for homogeneity of variances. Once the data met the assumptions of normality and homogeneity, the research hypotheses were tested using an independent-samples t-test to examine differences in learning outcomes between the experimental and control groups. All statistical analyses were performed using a significance level of 0.05 as the basis for hypothesis testing.

RESULT

This study aimed to determine the effect of Assemblr Edu-based Augmented Reality learning media on students' learning outcomes in the water cycle topic. The research findings are presented based on descriptive statistical analysis, assumption testing, hypothesis testing, and Normalized Gain (N-Gain) analysis to evaluate the improvement in students' learning outcomes.

Table 2. Descriptive Statistics of Pretest and Posttest Results

	N	Range	Minimum	Maximum	Mean	Std. Devation
Pretest	60	70	0	70	37.67	16.299
Postest	60	80	20	100	61.83	18.457
Valid N (listwise)	60					

Based on Table 2, the data analyzed were obtained from a total of 60 students. The pretest scores had a mean of 37.67, with a minimum score of 0, a maximum score of 70, a score range of 70, and a standard deviation of 16.299. Following the instructional intervention, the mean posttest score increased to 61.83, with a minimum score of 20, a maximum score of 100, a score range of 80, and a standard deviation of 18.457. The increase in the mean score indicates an improvement in students' learning outcomes after the learning process. Furthermore, the higher maximum score achieved on the posttest suggests that some students attained substantially better learning outcomes than they had demonstrated before the instructional intervention.

Table 3. Normality Test Results

Class	Result					
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
Postest A (Control)	.155	29	.072	.931	29	.057
Postest B (Experiment)	.165	31	.032	.953	31	.194

A normality test was conducted as a prerequisite for hypothesis testing to determine whether the data were normally distributed. The data were analyzed using the Kolmogorov–Smirnov and Shapiro–Wilk tests, with the Shapiro–Wilk results serving as the primary reference because each group consisted of fewer than fifty participants. As presented in Table 3, the posttest significance values were 0.057 for the control group and 0.194 for the experimental group, both of which exceeded the significance level of 0.05. Therefore, the posttest data for both groups were normally distributed, indicating that the normality assumption required for subsequent parametric statistical analyses was satisfied.

The homogeneity test was performed after the data met the assumption of normality, in order to determine whether the variances of the control group and the experimental group were equal. As shown in Table 4, the Levene's Test yielded a statistic of 0.650 with a significance value of 0.613. Since the significance value was greater than the established significance level of 0.05, the variances of both groups are considered homogeneous. This result indicates that there is no significant difference in variance between the control group and the experimental group. Therefore, the assumption of homogeneity is met, and the data are suitable for further analysis using an independent samples t-test to examine the differences in learning outcomes between the two groups.

Table 4. Independent Sample t-test Results

Variable	t	df	Sig. (2-tailed)	Mean Difference
Learning Outcomes	-7,879	58	0,000	-20,000

The hypothesis was tested using an Independent Samples t-test to examine the difference in learning outcomes between the control and experimental groups. As presented in Table 5, the analysis yielded a t-value of -7.879 with a significance value (Sig. (2-tailed)) of 0.000. Since the significance value was lower than the 0.05 significance level, there was a statistically significant difference in learning outcomes between students in the experimental and control groups. Therefore, the alternative hypothesis (H_1) was accepted, while the null hypothesis (H_0) was rejected.

DISCUSSION

The findings of this study indicate that the use of Assemblr Edu-based Augmented Reality learning media had a significant effect on students' learning outcomes in the water cycle topic. This result was confirmed by the findings of the independent samples t-test, which yielded a significance value of 0.000 ($p < 0.05$), indicating that the alternative hypothesis is accepted. Furthermore, the experimental group obtained a higher mean posttest score than the control group. This result was supported by the Normalized Gain (N-Gain) analysis, which showed that the experimental group achieved a moderate level of learning improvement, whereas the control group was classified in the low category. These findings demonstrate that the use of Assemblr Edu-based Augmented Reality learning media is more effective in improving students' learning outcomes than conventional instructional media.

The improvement in students' learning outcomes can be attributed to the characteristics of Augmented Reality (AR) technology, which integrates the real world with three-dimensional virtual objects, thereby providing students with more concrete learning experiences. In learning about the water cycle, students not only received verbal explanations from the teacher but also directly observed the processes of evaporation, condensation, precipitation, infiltration, and surface runoff through interactive three-dimensional visualizations. Such a presentation enabled students to better understand the relationships among the stages of the water cycle, concepts that are often difficult to comprehend when explained solely through two-dimensional images or lecture-based instruction. More realistic visualizations also allowed students to construct their understanding gradually, making the information easier to comprehend and retain.

These findings support the theory that instructional media serve as an effective means of delivering information, thereby enhancing the overall learning process. Learning media function not only as teaching aids for teachers but also as tools that increase students' attention, interest, motivation, and engagement during instruction. The implementation of Assemblr Edu-based Augmented Reality media enabled students to interact directly with learning materials through three-dimensional objects, shifting the focus of instruction from teacher-centered to student-centered learning. This approach is consistent with the principles of the Merdeka Curriculum, which emphasizes active, meaningful, and competency-based learning experiences.

The improvement in learning outcomes observed in the experimental group also indicates that the use of Assemblr Edu successfully reduced the abstract nature of the water cycle topic. One of the major challenges in elementary science education is that many scientific concepts cannot be directly observed by students. The water cycle is a continuous natural process, making it difficult for students to understand both the sequence and relationships among its stages. Through Augmented Reality, these processes were presented using animations and three-dimensional objects, enabling students to observe each stage more clearly. This visualization helped students connect theoretical concepts with real-life natural phenomena, thereby enhancing their conceptual understanding.

The results of this study align with the findings of the research by Jannah et al. (2025), who concluded that the use of interactive learning media based on Assemblr Edu has a positive impact on the cognitive learning outcomes of primary school students. Their study demonstrated significant differences in students' grades before and after using Assemblr Edu, indicating that these media effectively enhance the learning process. The consistency between the two studies suggests that Assemblr Edu can be applied across various learning topics because of its ability to present interactive three-dimensional objects that are easy for students to use. Nevertheless, the present study differs from the previous research in terms of the instructional topic and participant characteristics. While the previous study was conducted in a different educational context, this study specifically examined the water cycle topic among fifth-grade elementary school students. Therefore, the present study extends the empirical evidence regarding the effectiveness of Assemblr Edu in elementary science education.

The findings are also supported by the study conducted by Dian Nur Aini (2024), which demonstrated that the use of Augmented Reality-based learning media in teaching the water cycle significantly improved elementary school students' science learning outcomes. The study explained that three-dimensional visualization enabled students to understand the stages of the water cycle more concretely, making abstract concepts easier to comprehend. The similarity between the two studies lies in the use of Augmented Reality technology to visualize the water cycle. However, the difference lies in the instructional media employed. While Aini's study utilized Augmented Reality media in general, the present study specifically implemented Assemblr Edu, which offers interactive visualization features and is easily accessible for both teachers and students.

The results of this study are further supported by findings from Pannara (2026), who reports that augmented reality learning materials based on Assemblr Edu significantly improve the learning outcomes of fifth-grade students in science classes. The study found that students achieved higher grades after using Assemblr Edu than they did prior to the intervention, indicating that the media effectively enhanced conceptual understanding and academic achievement. According to the study, the visualization of three-dimensional objects enabled students to understand learning materials more easily because scientific concepts could be observed more realistically. Similar to the present study, Pannara's research emphasized the use of Augmented Reality technology to improve learning outcomes. However, the current study specifically utilized Assemblr Edu, which provides three-dimensional visualization, integrated images, text, and animations, and offers greater ease of use for both teachers and students. Consequently, the present findings provide further empirical evidence that Assemblr Edu is an effective Augmented Reality platform for improving elementary students' science learning outcomes.

The effectiveness of Assemblr Edu was further confirmed by the Normalized Gain (N-Gain) analysis, which indicated that the experimental group achieved a moderate level of improvement, whereas the control group remained in the low category. This difference suggests that learning

through Augmented Reality not only produced higher final achievement scores but also facilitated greater improvement throughout the learning process. These findings indicate that interactive learning media provide students with opportunities to construct knowledge progressively through meaningful learning experiences. In contrast, students in the control group, who received conventional instruction, remained largely dependent on teacher explanations, thereby limiting their opportunities to explore scientific concepts independently.

The results of this study have important implications for the implementation of science instruction (IPAS) in primary schools. Teachers can use augmented reality media based on Assemblr Edu as alternative learning tools, particularly for topics involving processes or objects that are difficult to observe directly. The use of this technology can improve the quality of instruction by providing students with more interactive, engaging, and contextual learning experiences. Furthermore, integrating digital technology into classroom instruction supports the implementation of the Merdeka Curriculum, which encourages the use of innovative instructional media to develop students' competencies in accordance with the demands of 21st-century learning. This study also contributes to the development of technology-based instructional media in elementary education. Unlike previous studies, which generally investigated the effectiveness of Augmented Reality across different science topics or educational levels, the present study specifically examined the use of Assemblr Edu-based Augmented Reality media in teaching the water cycle to fifth-grade elementary school students using a Nonequivalent Control Group Design. Therefore, this study provides additional empirical evidence that Assemblr Edu can serve as an effective instructional medium for improving students' learning outcomes in science education.

Overall, the findings demonstrate that the use of Assemblr Edu-based Augmented Reality learning media has a positive effect on students' learning outcomes in the water cycle topic. These findings reinforce previous research regarding the effectiveness of Augmented Reality in science education while providing further evidence that the implementation of Assemblr Edu supports more interactive, contextual, and student-centered learning. Therefore, Assemblr Edu deserves consideration as an innovative instructional medium that can be implemented by elementary school teachers to improve both the quality of the learning process and students' learning outcomes in Natural and Social Sciences (IPAS).

CONCLUSION

Based on the findings of this study, it can be concluded that the implementation of Assemblr Edu-based Augmented Reality media had a significant positive effect on students' learning outcomes in the water cycle topic among fifth-grade students at SD Negeri 1 Curug Wetan. This conclusion is supported by the statistical analysis, which revealed a significant difference in learning outcomes between the experimental and control groups. Furthermore, the N-Gain analysis indicated that students who learned using Assemblr Edu-based Augmented Reality achieved greater learning improvement than those who received conventional instruction. The use of this instructional media enabled students to better understand the abstract concept of the water cycle through interactive three-dimensional visualizations, making the learning process more engaging, meaningful, and easier to comprehend while encouraging active participation. Therefore, Assemblr Edu-based Augmented Reality can be considered an innovative and effective instructional medium for supporting IPAS learning at the elementary school level, particularly for topics requiring visual representation. Future research is recommended to investigate the implementation of this media in different subject areas, with larger sample sizes and diverse educational levels, as well as to examine its effects on other educational outcomes, such as learning motivation, critical thinking, creativity, and problem-solving skills, to provide a more comprehensive understanding of its effectiveness.

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