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The Effectiveness of the Augmented Story Experience Learning Media in Enhancing Elementary School Students' Ecological Citizenship in Pancasila Education

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ABSTRACT

This study aims to examine the effectiveness of the Augmented Story Experience learning media on elementary school students' ecological citizenship competencies in Pancasila Education. This study employs a quantitative approach using a quasi-experimental nonequivalent control group design. The research subjects were fifth-grade students at the UPI Cibiru Laboratory Elementary School, comprising an experimental class (n = 27) and a control class (n = 29). Research results: 1) The results of hypothesis testing based on Analysis of Covariance (ANCOVA) indicate a significant difference in the level of ecological citizenship competencies between the two groups after controlling for initial ability (pre-test) ($F(1, 53) = 51.984$; $p < 0.001$). Based on the Estimated Marginal Means analysis (with a pre-test mean of 43.21), the experimental group achieved a corrected post-test mean of 84.09, which was significantly higher than the control group's mean of 61.71. 2) The strategy for internalizing ecological citizenship values through the Augmented Story Experience learning media focuses on orientation, internalization, and subsequently, ecologically-minded civic actions, realized through an interactive 3D augmented reality narrative feature, "Special Mission," as well as the optimization of school ecosystem collaboration. The study concluded that the Augmented Story Experience learning media proved effective in enhancing elementary school students' ecological citizenship competencies and serves as a recommendation for environmentally friendly, digital technology-based innovations in Pancasila Education.

Keywords: Augmented Story Experience, Ecological Citizenship, Elementary School, Learning Media, Pancasila Education

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INTRODUCTION

The reality of an increasingly complex ecological crisis threatens the achievement of the Sustainable Development Goals (SDGs), particularly the environmental goals (SDG 13 and SDG 15). The National Footprint and Biocapacity Accounts indicate that Indonesia has a biocapacity of only 1.20 gha per capita, while its ecological footprint has reached 1.80 gha per capita, indicating an ecological deficit of 48% (Global Footprint Network, 2024). This imbalance has a tangible impact on ecological disasters striking various regions, leading to deforestation in 2025 covering an area of 433,751 ha, a drastic increase from 261,575 ha in 2024 (Auriga Nusantara, 2026). This surge in deforestation indicates that human consumption patterns are not aligned with conservation efforts, thereby exceeding nature's capacity to absorb waste and provide resources sustainably (Utami & Rahmayani, 2025).

Suboptimal environmental management and a decline in public awareness of nature conservation run counter to efforts to improve the quality of human capital (Tickamyer & Kusujiarti, 2025). This situation contradicts the empirically proven Environmental Kuznets Curve (EKC) hypothesis, which asserts that an increase in human capital can reduce ecological degradation once a certain tipping point is reached (Ahmed et al., 2020; Danish et al., 2020). The results of a preliminary study at the UPI Laboratory Elementary School on the Cibiru Campus indicate that, cognitively, the majority of students possess basic ecological knowledge; however, their ethical awareness and concrete pro-environmental actions still need to be improved. Educational interventions are essential to prevent this phenomenon from continuing, with a primary focus on developing moral reasoning and fostering ecological responsibility as the foundation of environmental ethics (Akhyar & Dewi, 2022). The existence of Pancasila Education at the elementary school level can be optimized as a strategic tool for fostering students' ecological citizenship competencies, thereby shaping a young generation that is environmentally conscious, exhibits pro-environmental behavior, possesses ecological literacy, and feels a moral obligation to take concrete actions to preserve nature (Bria et al., 2025; Fahmi et al., 2026).

Ecological citizenship as an ethical stance toward managing, preserving, and protecting natural ecosystems is essential for every individual, thereby ensuring that environmental sustainability and conservation are persistent and coherent (Gao, 2025). The terms ecological citizenship and environmental citizenship are often equated, but this is a misconception, as both concepts aim to achieve ecological balance (Humphreys, 2009). Philosophically, environmental citizenship is rooted in liberal citizenship, which holds that every citizen has the right to a clean and healthy environment; consequently, they also have obligations and are legally bound to comply with environmental regulations (Bell, 2005; Dobson, 2003). Ecological citizenship differs from environmental citizenship; its focus is more on moral awareness and socio-ecological responsibility regarding environmental conservation, which is not tied to legal sanctions or the pursuit of financial gain (Dobson, 2003). In other words, ecological citizenship leads citizens to behave and act in an environmentally friendly manner not out of fear of legal sanctions, but based on an internal ethical awareness. Apathetic citizenship, as the lowest level in the hierarchy of citizenship, contrasts with this ethical awareness; it is characterized by individuals who lack ecological concern, adopt a passive attitude, and are indifferent to environmental sustainability (Michiel et al., 2024).

The cultivation of ecological citizenship can be achieved through various strategic channels, such as formal education based on school curricula, community-based non-formal education, informal education, and integration through digital technology innovations (Nurdiansyah & Komalasari, 2023). The integration of ecological citizenship through learning must, at a minimum, involve the cognitive, affective, and psychomotor dimensions to ensure that students do not merely become passive observers but are also capable of serving as role models for an environmentally friendly lifestyle, promoting sustainable practices, and supporting pro-environmental policies (Syahri & Salahudin, 2024). This ecological citizenship-based learning not only focuses on understanding environmental theory but also instills civic character values, including civic responsibility, civic awareness, and pro-environmental behavior (Lestari et al., 2025). Pancasila Education needs to be transformed into contextual learning that fosters students' empathy and concrete actions to actualize the essence of ecological citizenship. This transformation shifts the teacher's role to that of a facilitator, motivator, and guide, thereby increasing students' civic engagement and transforming their understanding into civic action within the school environment (Mustapa, 2025).

Pancasila Education based on ecological citizenship is student-centered, contextual, and prioritizes civic engagement and civic character. Modifications through interactive learning approaches, such as gamification, are necessary for the implementation of Pancasila-based ecological citizenship education within the curriculum (Dichev & Dicheva, 2017; Gini et al., 2025). In practice, gamification integrates game elements, such as leaderboards, point systems, narratives, and branching challenges into the learning process (Huang et al., 2024; Rivera & Garden, 2021). Gamification in learning is personalized according to students' profile

preferences, competencies, autonomy, and learning needs; thus, it fulfills three essential elements of basic psychological needs that are crucial for driving behavioral change while simultaneously fostering students' intrinsic motivation (Bassanelli et al., 2022; Zeybek & Saygı, 2024). This adaptation of learning through digital gamification is not merely intended to fulfill the element of "joyful learning," but serves as a pedagogical strategy for fostering the competencies and ethics of responsible citizens (Mulyono et al., 2021), thereby making the process of internalizing the values of ecological citizenship more effective, participatory, and contextual. (Nguyen-Viet et al., 2024).

A gamification-based learning approach needs to be supported by media that can stimulate students' minds, attention, abilities, and emotions during the learning process. The use of appropriate media can facilitate the achievement of learning objectives, thereby impacting the quality and effectiveness of learning (El-Sabagh, 2021; Kalyani, 2024). There are various types of media that can be used, ranging from text, visual, audio, and video media to concrete objects and digital media (Heinich et al., 2002). Compared to other media, augmented reality stands out as a form of interactive multimedia innovation capable of visualizing objects and natural phenomena in a realistic manner. Augmented reality innovation serves as a strategic media choice in Pancasila Education grounded in ecological citizenship, given that abstract concepts such as ecological responsibility and environmental crises can be depicted more tangibly in the classroom.

The use of augmented reality, storybooks, and the promotion of ecological citizenship have been studied by previous researchers, for example, a study by Hutagalung and Rachman (2023), which developed an Android-based augmented reality tool for Civic Education instruction. Their findings confirm that 3D augmented reality visualization significantly enhances students' motivation, interest, and learning outcomes. The AR media designed in that study is still limited to the projection of static objects and has not yet addressed the dimension of interactive narratives. Another study specifically examined the strengthening of ecological citizenship in Pancasila and Civic Education by applying the Contextual Teaching and Learning (CTL) approach (Saragih et al., 2025). Contextual learning in this study was shown to be able to increase student participation in environmental conservation, albeit to a limited extent. Other studies involving augmented reality media have yielded similar findings, focusing solely on the visualization of content (Ibáñez & Delgado-Kloos, 2018; Şimşek, 2024), while research on strengthening ecological citizenship remains limited to conventional methods without the support of immersive media (Safitri et al., 2025). This situation highlights a research gap, as there have been few studies specifically examining the integration of augmented reality media with storytelling and gamification to foster ecological citizenship competencies in elementary schools.

To address this research gap, this study aims to examine the Augmented Story Experience (ASE) media innovation, which integrates Augmented Reality (AR) technology, narrative structure, and a gamification approach to foster ecological citizenship among students. This research focuses on fifth-grade elementary school students, based on the assumption that at this stage of development, transitioning from concrete to abstract operational thinking—students possess sufficient cognitive and moral readiness to internalize the values of ecological citizenship through immersive, interactive story-based media stimulus (Piaget & Inhelder, 1973). The novelty target is to test the effectiveness of the Augmented Story Experience learning media intervention, which combines interactive augmented reality technology with school-ecosystem-based civic action scenarios on the ecological citizenship competencies of elementary school students. Based on this framework, the research hypothesis posits that the Augmented Story Experience learning media is effective in enhancing students' ecological citizenship competencies, resulting in a difference in the level of ecological citizenship competencies between students in the experimental class, who received the Augmented Story Experience learning media-assisted intervention and those in the control class. The integration of the Augmented Story Experience is expected to transform Pancasila Education into a more meaningful, contextual, and environmentally sustainable learning experience.

METHOD

This research is based on a quantitative approach using a quasi-experimental nonequivalent control group design to examine the effectiveness of the Augmented Story Experience learning media on elementary school students' ecological citizenship competencies. Optimizing quantitative research through a quasi-experimental design makes the testing of the Augmented Story Experience learning media intervention more measurable, systematic, and objective, with the results verifying cause-and-effect relationships based on comparative evidence in pre-formed, qualified classes, making it relevant for use in educational research and learning media (Anantasia & Rindrayani, 2025). This study was conducted at the UPI Cibiru Laboratory Elementary School in Bandung Regency, based on the rationale that the school offers a diverse range of student characteristics and has the necessary technological infrastructure to support the implementation of the Augmented Story Experience learning media. The study population consisted of all fifth-grade students aged 10–11 years, and the research subjects were an experimental class (n = 27) using Augmented Story Experience learning media-assisted learning and a control class (n = 29) using slide presentation media-assisted learning. The research process consists of three main stages: the preparation stage (theoretical review, expert judgment, instrument pilot testing, and obtaining permits); the implementation stage (pre-test, media intervention, observation and limited interviews, and post-test); and the completion stage (descriptive analysis, prerequisite tests, hypothesis testing, and conclusions). Data collection methods included pre- and post-intervention written tests to assess the effectiveness of the Augmented Story Experience learning media, as well as observations and limited interviews regarding campaign strategies for promoting ecological citizenship values through the Augmented Story Experience learning media. The analysis of pre-test and post-test data was conducted using both descriptive and inferential methods, employing the ANCOVA (Analysis of Covariance) test, while observational and interview data were analyzed qualitatively and descriptively to support findings regarding strategies for the internalization of ecological citizenship values.

RESULT AND DISCUSSION

The Augmented Story Experience learning media innovation which integrates augmented reality technology, narrative structure, and gamification approaches into Pancasila Education in elementary schools is designed holistically to engage students' cognitive, affective, and psychomotor dimensions. The Augmented Story Experience learning media innovation in Pancasila Education has the potential to optimize strategies for transforming Pancasila values, particularly by turning social concern and environmental responsibility into concrete actions. The cultivation of ecological citizenship in this context aims to foster students' ecological awareness from an early age, so that they view themselves not merely as formal citizens but as ecological citizens who have a moral obligation to ensure the sustainability of a livable, balanced, and optimal environment in providing resources (Lestari et al., 2025; Nurdiansyah & Komalasari, 2023). This study focuses on two main areas. First, the significant potential of the Augmented Story Experience learning media to enhance elementary school students' ecological citizenship competencies. Second, the strategies for promoting the values of ecological citizenship, particularly in Pancasila Education in elementary schools.

To examine the effectiveness of the Augmented Story Experience learning media intervention in Pancasila Education at the elementary school level on students' ecological citizenship competencies, this quasi-experimental study involved two groups of participants: an experimental class (n = 27) and a control class (n = 29). The determination of these groups was based on inclusion and exclusion criteria to ensure internal validity and the completeness of the research data (Creswell & Guetterman, 2024). Details regarding the categories of criteria, indicators, and rationale for sample selection can be found in Table 1, as follows.

Table 1. Criteria, Indicators, and Rationale for Subject Selection

Criteria Category	Indicator	Rationale
Status Formal	Active 5th-grade elementary school students in the current semester (academic year 2026/2027).	Ensuring subjects are in Phase C according to the established Pancasila Learning Outcomes.
Inclusion Criteria	1. Participated in all intervention sessions; 2. Participated in the initial test (Pre-test) and final test (Post-test).	Ensuring subjects receive the complete treatment.
Exclusion Criteria	1. Absence > 25% during the intervention process; 2. Participated in only one test (pre-test or post-test only).	Ensuring subjects can participate in all activities optimally without basic technical obstacles.
Technical Suitability	Possess basic literacy and communication skills.	Ensuring subjects can interact smoothly with the learning media without technical constraints.

Based on Table 1, four criteria were considered in the selection of the sample for this study: formal status, inclusion criteria, exclusion criteria, and technical suitability. These criteria were selected to ensure that the sample adhered to the principle of representativeness of the target population and to guarantee full acceptance of the intervention during the study (Fraenkel et al., 2019).

Before the intervention was administered, students in the experimental and control groups were tested to assess their initial ecological citizenship competencies. The data collected prior to the intervention indicated that the students' ecological citizenship competencies still needed improvement. The experimental class received an intervention using the Augmented Story Experience learning media, while the control class received an intervention using a slide presentation. After the intervention was administered, the data showed an increase in students' ecological citizenship competencies, particularly in the experimental class that utilized the Augmented Story Experience. Students' ecological citizenship competencies in both the experimental and control classes were subsequently evaluated using N-Gain, which was calculated based on pre-test and post-test scores, as detailed in Table 2.

Table 2. Descriptive Analysis Results (Pre-test, Post-test, & N-Gain)

Group	N	Pre-test (Mean)	Post-test (Mean)	N-Gain (Mean)	N-Gain Category
Experimental	27	50.74	87.78	0.74	High
Control	29	36.21	58.28	0.41	Moderate

The data in Table 2 show that the control class experienced only a slight increase in the mean score, from 36.21 to 58.28, with an N-Gain of 0.41, which falls into the "Moderate" category. Meanwhile, the experimental class, which utilized the Augmented Story Experience learning media in its learning, experienced a fairly significant increase, from 50.74 to 87.78, with an N-Gain index of 0.74, classified as High. These descriptive data show a higher upward trend in the experimental group as well as differences in initial ability (pre-test) between the groups, indicating the need for further inferential analysis using ANCOVA (Analysis of Covariance) to statistically control for these biases.

Before testing the hypotheses, the prerequisites for ANCOVA were first evaluated, including tests of normality, homogeneity of variances, and homogeneity of regression slopes. The results of the normality test indicated that the residuals from the model were normally distributed ($p > 0.05$). The test for homogeneity of variances using Levene's Test yielded an F-value (1.54) = 0.017 with a p-value of 0.896 ($p > 0.05$), confirming that the variances across

groups were homogeneous. The results of the homogeneity of regression slopes test showed no significant interaction between pre-test scores and groups ($p > 0.05$), confirming that the linear relationship between the covariates and the dependent variable is parallel across groups.

After all prerequisite assumptions were met, a hypothesis test was conducted using analysis of covariance (ANCOVA) to examine differences in students' ecological citizenship competencies across groups after controlling for initial ability (pre-test). A summary of the ANCOVA results is presented in Table 3.

Table 3. ANCOVA Test Result

Source of variation	Type III Sum of Squares	*df*	Mean Square	F	Sig. (*p*)
Covariate (Pre-test)	1888.600	1	1888.600	19.279	< 0.001
Group (Treatment)	5092.365	1	5092.365	51.984	< 0.001
Error	5191.860	53	97.960		
Corrected Total	19250.000	55			

Note: $R^2 = 0.730$ (Adjusted $R^2 = 0.720$)

The ANCOVA results showed that initial ability (pre-test) acted as a covariate that significantly influenced students' post-test scores on ecological citizenship competencies (F (1, 53) = 19.279; $p < 0.001$), confirming the need to statistically control for pre-test bias. After controlling for the pre-test effect, the analysis results showed a significant difference in ecological citizenship competency achievement between the experimental and control groups ($F(1, 53) = 51.984$; $p < 0.001$).

Differences in students' ecological citizenship competencies between groups were measured using Estimated Marginal Means (corrected means), evaluated relative to the mean covariate (Pre-test= 43.21). The corresponding mean results are presented in Table 4.

Table 4. Estimated Marginal Means of Ecological Citizenship Competency

Group	Corrected Post-test Mean	Standard Error (SE)	95% Confidence Interval	
			Lower Bound	Upper Bound
Experimental	84.09	2.08	79.92	88.27
Control	61.71	2.00	57.70	65.72

The results in Table 4 show that the experimental group achieved a corrected post-test mean of 84.09 (SE = 2.08), while the control group achieved a corrected post-test mean of 61.71 (SE = 2.00), which is significantly lower than the experimental group's score. In addition, the coefficient of determination was $R^2 = 0.730$, indicating that 73.0% of the variation in students' ecological citizenship competencies was jointly explained by pre-test scores and differences in instructional treatments. These results demonstrate that the Augmented Story Experience learning media intervention in the experimental group had a significant effect on improving ecological citizenship competencies compared to the slide presentation-based intervention in the control group. The significant findings in the experimental class are supported by the theory stating that ecological citizenship-based learning is optimal when implemented using a student-centered, contextual approach that prioritizes civic engagement and civic character (Dichev & Dicheva, 2017). In addition to fulfilling the three basic psychological needs (cognitive, affective, and psychomotor), this learning approach is capable of fostering behavioral change while simultaneously stimulating students' intrinsic motivation (Bassanelli et al., 2022; Syahri & Salahudin, 2024; Zeybek & Saygı, 2024). The Cognitive Theory of Multimedia Learning (Mayer, 2009) reinforces the finding that the immersive 3D visualizations and interactivity provided by the Augmented Story Experience learning media stimulate students' audio-visual-kinesthetic engagement. This reality facilitates the process of internalizing ecological citizenship without

overburdening working memory capacity. The success of using this interactive learning media is influenced by a combination of multimedia elements that can adapt to students' diverse characteristics and needs (Galand & Nanggala, 2023), moreover, the use of digital literacy promotes the internalization of students' moral responsibility values in the modern era (Dewi et al., 2021). The alignment between theory and the findings of this study confirms that the use of the Augmented Story Experience learning media is effective in enhancing students' ecological citizenship competencies in Pancasila Education in elementary schools.

In addition to findings based on quantitative data, qualitative data reveal that the process of internalizing the values of ecological citizenship in the experimental classroom was carried out systematically through the use of the Augmented Story Experience, which combines contextual stories set in family, school, and community environments, as well as social media, using augmented reality technology. The initial strategy focused on introducing the values of ecological citizenship through the exploration of physical storybooks based on the Augmented Story Experience, which feature illustrated narratives, voice-overs, and interactive 3D objects. This multisensory intervention aligns with the Psychology of Narrative theory, which explains that stories (literary works) are mental simulations capable of inviting readers to observe, understand, and then model human interactions in concrete terms (Oatley & Djikic, 2018). Through interactive augmented reality features, students can manipulate digital objects, such as zooming in and out, viewing simulations and tutorials, and even taking quizzes. This audio-visual approach fosters a high level of curiosity and civic engagement, allowing students to focus on exploring each chapter without feeling overwhelmed by rigid and monotonous material (Observational Study Results, July 2026). Other interactive features, such as Quiz Time, Crossword Puzzles, Word Searches, and Summaries of Learned Values, indirectly help students better absorb the targeted ecological moral messages (Results of Interview with AA, July 2026).

The second strategy for internalizing the values of ecological citizenship is the internalization of values. Storylines that are familiar to students' daily lives encourage a more personal internalization of values, enabling them to easily understand and associate events in the story with ecological actions they have taken or could take (Slater et al., 2019) (Interview with RY, July 2026). Interactive narratives employ mechanisms of foregrounding and indirect communication to stimulate empathy and the mental capacity to understand the perspectives, thoughts, and feelings of the surrounding environment without coming across as patronizing or judgmental (Oatley & Djikic, 2018). Through this approach, the process of understanding values occurs independently and naturally, since the message is not imposed from the outside (by the teacher); rather, readers discover this awareness on their own through interactive experiences (Findings from an Observational Study, July 2026). This finding is supported by research suggesting that for elementary school-aged children, visual media-based stories can foster reflection on values and strengthen competencies (Stolk et al., 2025). Experiences with Augmented Story Experience content such as tutorials on making compost, creating crafts from waste, and learning about the environmental impacts of neglect can stimulate students' empathy toward environmental conditions (Observational Study Results, July 2026). This demonstrates that the Augmented Story Experience learning media can bridge the gap between students' initial awareness and the development of civic responsibility regarding environmental sustainability.

The third strategy which also serves as the culmination of efforts to internalize the values of ecological citizenship is the promotion of sustainable, competent, and voluntary civic actions. Through the "Special Mission" feature and a review of the material covered at the end of each chapter, students are not only expected to understand and empathize but are also expected to carry out integrated ecological actions. The sustainability of these civic actions through "Special Missions" is supported by the teacher's role as a facilitator who oversees and optimizes the school environment, such as through collaboration with various existing extracurricular programs. The missions of sorting waste and caring for plants are optimized through collaboration with the Labschool Go Green Community, while the mission of digital campaigns for the ecological movement is optimized through collaboration with the Cinematography, Photography, and Broadcasting extracurricular programs (SF Interview Results, July 2026). The

use of digital campaigns in this "Special Mission" is designed to facilitate the participation and civic engagement of the younger generation in civic issues (Tarsidi et al., 2023). This civic-action-based strategy aligns with the principle of experiential learning, which reveals that deep understanding occurs when students are actively and directly involved (learning by doing) (Li et al., 2023). The civic engagement fostered through this "Special Mission" ensures that the values of ecological citizenship do not merely become passive knowledge that is easily forgotten, but also become competencies and a mindset that guide their actions (Findings from the Observational Study, July 2026). The novelty of this research is evident in the testing of the effectiveness of a learning intervention aided by the Augmented Story Experience a learning media that not only integrates narrative and interactive augmented reality with civic action but also synergizes with the school ecosystem. This differs from previous studies, which generally tested augmented reality media as a tool for visualizing passive 3D objects (Hutagalung & Rachman, 2023; Ozturk & Akcay, 2023). The "Augmented Story Experience" learning media intervention in this study evaluates the extent to which narrative and interactive augmented reality stimuli can transform ecological knowledge into attitudes and concrete actions, thereby fostering ecological citizenship competencies in a holistic manner. The intervention scenarios and mechanisms tested in this study are systematically presented in Figure 1.

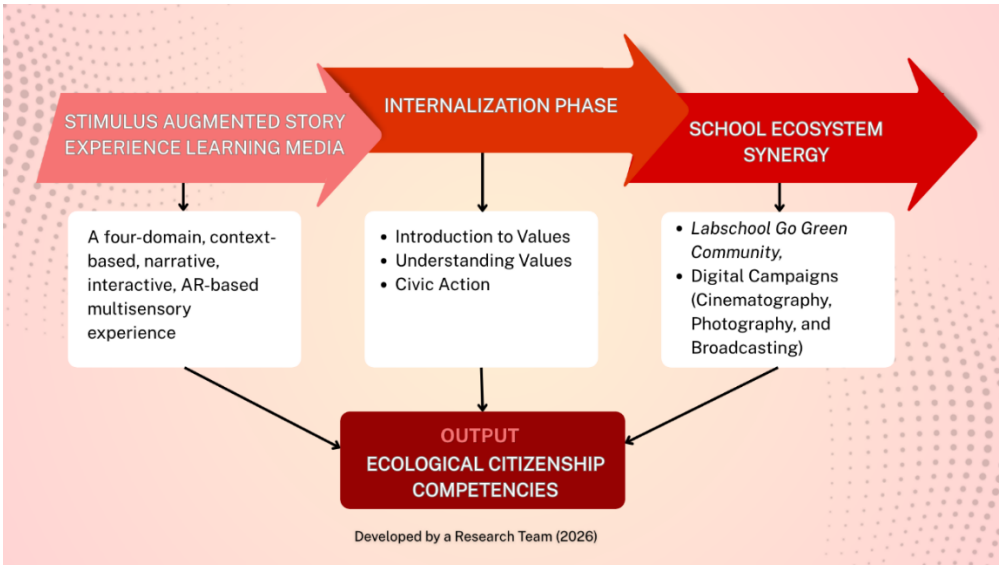


Figure 1. The Process of Internalizing Ecological Citizenship Competency Values Through an Augmented Story Experience-Based Learning Media Approach

Based on Figure 1, the process of internalizing ecological citizenship values encompasses three main aspects: media stimuli, the internalization stage, and school ecosystem synergy. The Augmented Story Experience learning media stimulus focuses on interactive multisensory experiences that present contextual narratives within the family, school, community, and social media environments, complete with 3D augmented reality objects, voice-overs, as well as activity sheets and interactive ecological quizzes. The internalization stage focuses on the introduction, internalization, and subsequent concrete action based on the values and competencies of ecological citizenship. Synergy within the school ecosystem, achieved through the optimization of relevant extracurricular activities, serves as a platform for students to carry out the "Special Mission" instructions from the Augmented Story Experience platform. The missions of waste sorting and plant care are optimized through collaboration with the Labschool Go Green Community, while the mission of the digital campaign for the ecological movement is optimized through collaboration with the Cinematography, Photography, and Broadcasting extracurricular programs. The interdependence of these three aspects in the

internalization process ensures that ecological values do not remain merely as knowledge or rote memorization, but are transformed into concrete actions and sustainable habits.

The main findings of this study confirm that the use of the Augmented Story Experience learning media is significantly more effective in improving elementary school students' ecological citizenship competencies compared to slide presentations. This level of effectiveness is demonstrated by the corrected post-test scores and the increase in the experimental group's N-Gain, which reached the "High" category. The relevance of these research findings makes an important contribution to the field of education, particularly in addressing the challenges of low ethical awareness and a lack of concrete pro-environmental actions at the elementary school level. The novelty of this research lies in testing the effectiveness of a learning intervention supported by the Augmented Story Experience learning media, which not only integrates narrative and interactive AR with civic action but also synergizes with the school ecosystem.

In comparative terms, the findings of this study confirm the success of the intervention and the consistency of the statistical improvements related to the use of augmented reality media reported by several previous researchers, such as the quasi-experimental study by Arici (2024), Shakirova et al. (2024), and Şimşek (2024) demonstrated that augmented reality technology significantly improves conceptual understanding of the environment, boosts motivation to learn, and optimizes the learning load. A study by Pithaloka et al. (2025) using a one-group pretest-posttest methodology, also demonstrated that the use of augmented reality-based media is effective in improving environmental literacy, although the significance value of 0.255 (not significant) was attributed to limitations in the duration of the intervention, the complexity of the content, and students' digital readiness and skills. Hudha et al. (2026) and Agustin et al. (2026) also confirmed that augmented reality media not accompanied by structured activities often fails to have a significant impact on real-world behavior. These findings reinforce the notion that while augmented reality technology is effective in improving the variables under study, optimizing results depends on the appropriateness of integration strategies, subject selection, and research planning.

A common pattern observed in the findings is that augmented reality's immersive visualization enhances students' understanding of ecological concepts by transforming abstract phenomena into more concrete ones. In practice, there are several differences that distinguish this study from previous research, such as the expansion of the environmental literacy variable to include "ecological citizenship" in Pancasila Education, which not only fosters basic ecological understanding but also integrates ecological knowledge, civic responsibility, and civic action. This difference is fundamentally influenced by the academic discipline, as most previous studies placed the media within science or environmental education instruction (Agustin et al., 2026; Şimşek, 2024), whereas this study integrates the media into Pancasila Education. Another difference is evident in the synergy of the school ecosystem. The majority of previous studies implemented interventions in isolation within classrooms or computer labs (Layyinah et al., 2026), whereas this study optimizes the interaction of digital media with the culture and environmental infrastructure at the UPI Cibiru Laboratory Elementary School. Collaboration through the school ecosystem serves as a reinforcement system that fosters the continuity of students' "Special Mission," thereby ensuring that the internalization of ecological citizenship values becomes a sustainable habit.

The use of the Augmented Story Experience platform in this study expands the scope of augmented reality technology, which previously dominated the field of science education—to the realm of citizenship grounded in ecological values. Pancasila Education that integrates immersive digital technology, narrative structures, and action-based gamification approaches has proven effective in enhancing citizens' competencies regarding ecological sustainability. Theoretically, the research findings contribute data toward bridging the gap between digital literacy and ecological citizenship competencies in Pancasila Education. These findings emphasize that AR technology serves not only as a passive visualization tool but also as a primary stimulus for transforming Pancasila Education into an interactive, meaningful, contextual, and accommodative learning experience that supports environmental sustainability. In practice, the success of this study has implications for educators to adopt story-based

immersive learning media and optimize the school ecosystem to support students' concrete actions. For policymakers, the study's findings can serve as a basis for curriculum development, particularly in Pancasila Education, to integrate digital innovations that support environmental sustainability.

This study has limitations due to its relatively small sample size (n = 56) and its focus on a single educational institution (UPI Cibiru Laboratory Elementary School); therefore, generalizations to schools with different facilities and cultures should be carefully considered. As a recommendation, future research should test the effectiveness of the Augmented Story Experience learning media intervention on a broader and more heterogeneous population. It is also recommended that future research conduct a long-term study to evaluate the sustainability of ecological citizenship habits in daily life.

CONCLUSION

The Augmented Story Experience learning media proved effective in enhancing students' ecological citizenship competencies, as evidenced by the experimental class's scores, which were significantly higher than those of the control class. The primary strategy for internalizing ecological citizenship values focuses on introduction, internalization, and then ecologically-minded civic actions through various features of the Augmented Story Experience, which holistically integrates contextual stories, interactive augmented reality technology, and "Special Missions" that guide students to take concrete action for their local environment. This study innovatively designed an augmented reality-based learning scenario that not only deeply transformed ecological knowledge but also successfully encouraged students to take concrete action through collaboration with the Labschool Go Green Community, as well as a digital campaign with the school's cinematography, photography, and broadcasting teams. The research findings provide practical implications for educators to optimize the use of narrative-based interactive media that engages students and empowers the school ecosystem, thereby transforming Pancasila Education into an interactive, meaningful, contextual, and accommodative process that supports environmental sustainability. Further research is recommended to test the effectiveness of the Augmented Story Experience learning media on a broader scale and to evaluate the long-term retention and habituation of ecological citizenship competencies.

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