



# The Effectiveness of Ecoviar (Ecosystem via Augmented Reality) Learning Media in Enhancing Students' Computational Thinking and Scientific Literacy

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## ABSTRACT

**Objective:** The objective of this study was to assess the effectiveness of ECOVIAR (Ecosystem via Augmented Reality) learning media in improving elementary school students' Computational Thinking and scientific literacy skills on ecosystem material.

**Method:** A quasi-experimental design with a non-equivalent control group design was used in this study. A total of 60 fifth-grade students participating in the experimental class and the control class were used as the research sample. The experimental class was given treatment using ECOVIAR media, while the control class underwent conventional learning. Data were collected using a validated long-response test to measure Computational Thinking and scientific literacy. Data analysis was calculated using a normality test, a homogeneity test, and an independent sample t-test. **Results:** The findings indicated no significant difference in the initial abilities between the two groups ( $Sig. > 0.05$ ). However, significant differences were found in the post-test results for both computational thinking ( $Sig. = 0.002 < 0.05$ ) and scientific literacy ( $Sig. = 0.000 < 0.05$ ). It is concluded that students taught using ECOVIAR media achieved significantly higher learning outcomes compared to those in the conventional learning group. **Novelty:** The development and utilization of Augmented Reality media in learning specifically designed for the ecosystem of learning materials with a focus on improving Computational Thinking and scientific literacy is a novelty in this study, because it is still rarely studied simultaneously in elementary school expansion.

## INTRODUCTION

Natural and Social Sciences (IPAS) at the elementary level aim to equip students with scientific conceptual understanding and foster a scientific attitude, enabling them to respond to surrounding natural phenomena (Kemendikbud, 2022). A pivotal topic in the fifth-grade curriculum is ecosystem harmony, which emphasizes the reciprocal relationships between living organisms and their environment (Maula & Agustyarini, 2024). This topic provides a fundamental basis for students to comprehend nature as an interdependent system (Pane et al., 2022). From a developmental perspective, fifth-grade students are situated within Piaget's concrete operational stage, where they begin to grasp cause and effect relationships through real world phenomena (Piaget, 1969). While this contextual topic is integral to shaping ecological awareness (Mahardika & Siswoyo, 2021), pedagogical practice often reveals that science instruction at the elementary level is still perceived as monotonous and difficult for students to comprehend (Alfatonah et al., 2023).

Extant research indicates that students' disinterest in science stems from its perceived complexity and abstraction, particularly regarding ecosystem concepts (Kuroru & Rahmah, 2023; Wahyuni, Hariandi, et al., 2023). These topics involve abstract ecological processes that are often challenging to grasp through verbal explanations or static textbook imagery alone (Nasir et al., 2018; Qorimah et al., 2022). Quantitatively, international benchmarks such as the Programme for International Student Assessment

(PISA) reflect this struggle, that Indonesian students' scientific literacy scores remain significantly below the global average, with a mean of 383 compared to 449 (OECD, 2023). Specifically, only 34% of Indonesian students achieve the minimum proficiency (Level 2) in science, indicating a limited capacity to understand scientific phenomena contextually or through evidence-based reasoning.

Aligning with the Phase C Science Learning Outcomes, specifically within the theme of ecosystem harmony, students are expected to investigate the relationships between biotic and abiotic components while holistically comprehending the interconnectedness of ecosystem processes (Kemendikbud, 2022). The learning objectives in Subtheme 1 (Food Chains and Food Webs) require students to analyze component interactions, a process cognitively intertwined with computational thinking (CT) skills, including problem decomposition, pattern recognition, and system modeling (Wahyuni, Rofingah, et al., 2023). Furthermore, Subtheme 2 (Energy Flow in Ecosystems) prompts students to predict energy transfer patterns across trophic levels, necessitating conceptual understanding, scientific data interpretation, and evidence-based decision making. These competencies fall within the domain of scientific literacy, specifically the ability to explain scientific phenomena and evaluate their real world impact (Gultom & Alwi, 2024). Consequently, an ideal pedagogical approach must target both conceptual mastery and the cultivation of scientific and computational thinking skills, ultimately supporting the realization of the Pancasila Student Profile.

A comparison between the ideal pedagogical standards and the actual classroom conditions in fifth-grade science education reveals a substantial gap. Ideally, science instruction should be a contextual and engaging process that cultivates students' critical thinking and conceptual mastery. However, the prevailing reality indicates that science learning remains largely conventional, abstract, and uninspiring. Particularly in ecosystem studies, students struggle to comprehend the complex interrelationships between components and energy flow due to the dearth of concrete and interactive visual media (Mahardika & Siswoyo, 2021; Pane et al., 2022; Reizal et al., 2020). In elementary school learning, the integration of 21st century skills has become increasingly imperative, as students must be equipped with critical, systematic, and evidence based problem solving competencies (Abduh & Istiqomah, 2021). Both computational thinking (CT) and scientific literacy are integral to these 21st-century demands within the realms of science and technology (Azizah et al., 2023; Gultom & Alwi, 2024). CT serves as a fundamental cognitive framework, enabling students to analyze and resolve problems systematically through decomposition, pattern recognition, abstraction, and algorithmic design (Maulana et al., 2023). Concurrently, scientific literacy empowers students to grasp scientific concepts, reason through evidence, and make informed decisions based on valid data (Aditya & Indana, 2021).

This study aims to evaluate the effectiveness of ECOVIAR (Ecosystem via Augmented Reality) learning media in fostering students' computational thinking (CT) and scientific literacy. The originality of this research resides in the implementation of the ECOVIAR media, which was specifically engineered to support the fifth-grade science theme, 'Harmony in Ecosystems,' and has undergone rigorous feasibility testing (Cendani et al., 2025). By presenting ecosystem content through interactive visual simulations, this media is designed to stimulate higher order thinking skills (HOTS). A distinctive feature of this study is its simultaneous focus on CT and scientific literacy, two pivotal 21st century competencies that remain underexplored as concurrent primary variables in elementary science education. Consequently, this research provides a significant contribution to the

Merdeka Curriculum (Kurikulum Merdeka) and remains highly relevant to both current and future educational demands.

## RESEARCH METHOD

This study employed a quasi-experimental design, specifically utilizing a non-equivalent control group configuration. The experimental group received instruction via ECOVIAR (Ecosystem via Augmented Reality) media, whereas the control group followed conventional learning procedures. The study population comprised fifth-grade students at Lidah Kulon 1 Public Elementary School during the 2025/2026 academic year. Through cluster random sampling, two classes were selected as the research sample, totaling 60 students divided into experimental and control groups. Data collection was facilitated by a validated instrument consisting of eight descriptive items (extended response questions). This instrument was strategically bifurcated: four items targeted computational thinking (CT) indicators, while the remaining four items assessed scientific literacy (SL) (Table 1). Assessment was conducted in two phases: a pre-test prior to the intervention and a post-test following the treatment.

**Table 1.** Research variable indicators (Almeida et al., 2023; Hurd, 1982; Wing, 2006)

| Variable               | Indicator  | Item Number |
|------------------------|--|-------------|
| Computational thinking | Decomposition  | 1           |
|                        | Pattern Recognition  | 2           |
|                        | Abstraction  | 3           |
|                        | Algorithms   | 4           |
| Scientific literacy    | Understanding Scientific Concepts                                      | 5           |
|                        | Scientific Inquiry   | 6           |
|                        | Evidence Based Decision Making   | 7           |
|                        | Awareness of the Relationship between Science, Technology, and Society | 8           |

To evaluate the effectiveness of ECOVIAR media, hypothesis testing was performed following the verification of data normality and homogeneity of variance. Data analysis followed a quantitative approach utilizing the Independent Sample t-test. This statistical technique was employed to determine if significant differences existed in computational thinking and scientific literacy outcomes between the two groups following the intervention.

## RESULTS AND DISCUSSION

### Results

The results of the ECOVIAR learning media effectiveness test in improving the Computational Thinking of fifth-grade elementary school students on ecosystem material were determined by analyzing the results of the pre-test and post-test. These assessments were administered to both the control and experimental classes. Initially, both groups were given a pre-test to assess their initial abilities. Each class received the same treatment, with the only differences being the type of media utilized and the instructional design. The control class received instruction using conventional media typically employed by teachers, such as PowerPoint presentations and textbook readings. Prior to the analysis, a normality test was conducted as a prerequisite for evaluating the pre-test results (Table 2).

**Table 2.** Computational thinking data normality test results

| Group                  | Statistic | df | Sig.  |
|------------------------|-----------|----|-------|
| Experimental Pre-Test  | 0.931     | 24 | 0.102 |
| Experimental Post-Test | 0.950     | 24 | 0.268 |
| Control Pre-Test       | 0.971     | 24 | 0.697 |
| Control Post-Test      | 0.967     | 24 | 0.590 |

The data were determined to be normally distributed because the significance value exceeded  $> 0.05$ . The homogeneity test was also a prerequisite and was conducted to assess the equality of variance between sample groups.

**Table 3.** Computational thinking data homogeneity test results

| Group  | Levene Statistic | df1 | df2 | Sig.  |
|--|------------------|-----|-----|-------|
| Pre-test for the Control and Experimental Group  | 2.128            | 1   | 46  | 0.151 |
| Post-test for the Control and Experimental Group | 0.117            | 1   | 46  | 0.733 |

Table 3 represents the sig. Based on Mean value of 0.151 for the pre-test and 0.733 for the post-test. Based on the theory of significance value  $> 0.05$ , the data distribution is homogeneous so that it is concluded that the variance of the pre-test and post-test experimental and control data is the same, thus fulfilling the prerequisites for the independent sample T-test. The Independent Sample t-test was conducted as a basis for assessment by knowing the difference in the average learning outcomes between two unpaired samples, in this case the experimental group given ECOVIAR media and the control group given learning as usual using textbook media.

**Table 4.** Computational thinking data t-test results

|  |                             | t      | df     | Sig, (2-tailed) | Mean Difference |
|--|-----------------------------|--------|--------|-----------------|-----------------|
| Pre-test results for the control and experimental group  | Equal variances assumed     | -1.199 | 46     | 0.237           | -1.406250       |
|  | Equal variances not assumed | -1.199 | 40.437 | 0.238           | -1.406250       |
| Post-test results for the control and experimental group | Equal variances assumed     | 3.238  | 46     | 0.002           | 4.115           |
|  | Equal variances not assumed | 3.238  | 45.67  | 0.002           | 4.115           |

The results of the Independent Sample t-test are clearly represented in Table 4. obtained a pretest Sig. (2-tailed) value of 0.237 ( $> 0.05$ ) for Computational Thinking, so it is concluded that there is no significant difference between the initial Computational Thinking of students in the experimental group and the control group, so that their initial abilities are equal. For the posttest data, a Sig. (2-tailed) value of 0.002 ( $< 0.05$ ) was produced, with this value it is concluded that there is a significant difference in the Computational Thinking values of the experimental group given ECOVIAR media and the control group given learning as usual using textbook media. The results of the effectiveness test of Ecoviar learning media to improve the scientific literacy of students

in grade V of elementary school on ecosystem material were also carried out by looking at the results of the pre-test and post-test that had been given.

**Table 5.** Results of the normality test of science literacy data

| Group                  | Statistic | df | Sig.  |
|------------------------|-----------|----|-------|
| Experimental Pre-Test  | 0.958     | 24 | 0.399 |
| Experimental Post-Test | 0.929     | 24 | 0.092 |
| Control Pre-Test       | 0.957     | 24 | 0.376 |
| Control Post-Test      | 0.968     | 24 | 0.620 |

Decision making for the normality test is based on a significance value  $> 0.05$ , indicating that the data is normally distributed (Azwar, 2017). Because the overall significance result is greater than 0.05, the data is normally distributed (Table 5). Therefore, the prerequisites are met, and the homogeneity testing process can be continued.



**Figure 1.** Display Ecoviar (Ecosystem via Augmented Reality) Learning Media

**Table 6.** Results of the homogeneity test of science literacy data

| Group  | Levene Statistic | df1 | df2 | Sig.  |
|--|------------------|-----|-----|-------|
| Pre-test for the Control and Experimental Group  | 0.358            | 1   | 46  | 0.553 |
| Post-test for the Control and Experimental Group | 2.422            | 1   | 46  | 0.127 |

**Table 7.** Results of the t-test of science literacy data

|  |                             | t      | df     | Sig. (2-tailed) | Mean Difference |
|--|-----------------------------|--------|--------|-----------------|-----------------|
| Pre-test results for the control and experimental group  | Equal variances assumed     | 0.513  | 46     | 0.610           | 0.5208          |
|  | Equal variances not assumed | 0.513  | 44.942 | 0.610           | 0.5208          |
| Post-test results for the control and experimental group | Equal variances assumed     | -5.642 | 46     | 0.000           | -5.938          |
|  | Equal variances not assumed | -5.642 | 43.39  | 0.000           | -5.938          |

Based on the prerequisite test results in Table 6, the data is declared homogeneous because the sig. Based on Mean value is 0.151 for the pre-test and 0.733 for the post-test (the significance value is  $> 0.05$ , so the data distribution is homogeneous) so that the independent samples t-test can be carried out. On the scientific literacy variable, the analysis was carried out to determine whether there is a difference in the average learning

outcomes between the experimental group using ECOVIAR media and the control group using conventional textbook-based learning.

The results of the Independent Sample t-test of the scientific literacy variable are clearly represented in Table 7. The pretest obtained a Sig. (2-tailed) value of 0.610 ( $> 0.05$ ), it was concluded that there was no significant difference between the initial abilities of the Science Literacy of students in the experimental group and the control group, so that their initial abilities were equal. For the posttest data, a Sig. (2-tailed) value of 0.000 ( $< 0.05$ ) was produced, with this value it was concluded that there was a significant difference in the Science Literacy values of the experimental group given ECOVIAR media and the control group given learning as usual using textbook media.

## Discussion

The effectiveness of ECOVIAR learning media in improving students' Computational Thinking (CT) skill was analyzed based on the results of the pretest and posttest after the ECOVIAR media were declared feasible at the development stage. The tests that have been carried out significantly show that there is an increase in the CT skill of students who have been given learning treatment using ECOVIAR media. The data generated from the statistical test obtained a Sig. (2-tailed) value of 0.002  $< 0.05$ , which indicates that there is a significant difference between the CT values before and after treatment. Thus, it is concluded that the use of ECOVIAR learning media is effective in improving students' Computational Thinking skills. This improvement is attributed to the inherent characteristics of ECOVIAR media, which integrates 3D ecosystem objects and exploratory activities that assist students in building understanding through direct observation. AR visualizations facilitate students in deconstructing ecosystem components in a structured manner, recognizing food chain and energy flow patterns, and constructing logical reasoning to comprehend the relationships between ecosystem components. Through this experience, students directly practice CT skills such as decomposition, pattern recognition, abstraction, and algorithmic thinking. Interactive features, such as scanning markers, observing virtual objects, and drawing conclusions independently, encourage students to think systematically without relying solely on verbal explanations from the teacher. These findings align with MZ et al. (2022), who explained that AR enables students to interact directly with virtual objects within a real-world context, thereby helping them analyze relationship patterns more comprehensively (MZ et al., 2022).

Similarly, Bocconi et al. (2022) stated that AR-based learning experiences can strengthen abstraction and simple algorithm development skills because students can generalize patterns observed within virtual environments (Bocconi et al., 2022). This aligns with the learning process using ECOVIAR, where students predict energy flows and ecosystem interactions based on visual patterns displayed through AR. Previous research further supports these findings. For instance, Triswidrananta et al. (2024) demonstrated that the use of AR in mathematics instruction can significantly improve students' CT through increased n-gain. Although the fields of study differ, the principles of interacting with 3D objects and the real-world implementation used in that study demonstrate strong relevance to learning assisted by ECOVIAR (Triswidrananta et al., 2024).

Regarding scientific literacy, data were obtained through pre-test and post-test results within the experimental group participating in learning using ECOVIAR. Based on the statistical test results, the Sig. (2-tailed) value was 0.000 ( $< 0.05$ ). This indicates a

significant increase in scientific literacy scores before and after the use of ECOVIAR in the learning process. Thus, it can be concluded that ECOVIAR media is proven to have a significant influence on increasing the scientific literacy of fifth-grade students. This improvement is related to the characteristics of ECOVIAR as an Augmented Reality (AR) learning media capable of visualizing ecosystem concepts in a concrete, dynamic, and interactive manner. The 3D visualizations in ECOVIAR assist students in clearly observing the relationships between ecosystem components ranging from food chains and energy flow to biotic and abiotic interactions, which were previously difficult to comprehend through static images and textbooks. The findings of this study align with several previous research works. Zaid et al. (2022) demonstrated that STEAM-based AR learning media effectively improved the quality of science instruction, yielding a gain value of 0.72. This enhanced instructional quality directly impacted the understanding of scientific concepts, which serve as the foundation for scientific literacy (Zaid et al., 2022). Furthermore, Wiliyanti et al. (2024) confirmed that AR-based media consistently improves students' conceptual mastery, particularly regarding material that is inherently difficult to visualize (Wiliyanti et al., 2024). These findings support the implementation of ECOVIAR, which concretely visualizes ecosystem concepts through 3D models, thereby strengthening students' comprehension of scientific phenomena.

Research by Uno (2024) also confirmed that AR-based interactive media effectively enhances elementary students' understanding of science concepts (Uno, 2024). This improved conceptual grasp contributes significantly to scientific literacy, as students do not merely memorize facts but also comprehend the processes and interrelationships of concepts. Moreover, Rachim et al. (2024) found that AR utilization increases student engagement (Rachim et al., 2024). Such engagement is closely linked to scientific exploration, a key component of scientific literacy that requires students to observe, identify phenomena, and draw evidence-based conclusions. Consequently, it can be concluded that AR based learning media holds immense potential for advancing scientific literacy. By utilizing AR to visualize complex science concepts and encouraging exploration and reasoning, ECOVIAR provides a robust foundation for improving conceptual understanding and student interest. Therefore, this study confirms that ECOVIAR is an effective tool for improving the scientific literacy of elementary school students.

## CONCLUSION

**Fundamental Finding:** The use of Ecoviar (Ecosystem via Augmented Reality) learning media is significantly effective in improving the computational thinking and scientific literacy of elementary school students. The results of the study provide a basis for obtaining the independent samples t-test results for the initial abilities of the control and experimental groups, which are the same as the pre-test results (Sig. > 0.05), while significant differences were identified through the post-test results (Sig. < 0.05) in both variables. **Implikasi:** The findings suggest that utilizing Augmented Reality-based media, such as ECOVIAR, serves as a viable alternative for enhancing the quality of science instruction in primary education. The integration of ECOVIAR into the curriculum has been proven to foster active student engagement while simultaneously advancing computational thinking and scientific literacy. **Limitation:** The study's limited scope, limited to a single school and a small sample size, means that generalizations of the results require caution. The short duration of treatment also means that the long-term impact of Ecoviar media use on student skill development cannot be fully elucidated.

**Future Research:** Future research is recommended to expand the sample scope by involving multiple schools and diverse student characteristics to enhance external validity. Furthermore, longitudinal studies are necessary to examine the long term effects of using AR based learning media like ECOVIAR on the sustained development of 21st century skills.

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