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Development of smart apps creator based on computational thinking skills in ecosystem topics at MI Al-Fattah Malang

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Abstract
Science and Social Studies (IPAS) learning on ecosystem topics in Grade V at MI Al-Fattah Malang remains teacher-centered, underutilizes digital technology, and has not integrated Computational Thinking Skills (CTS). As a result, students struggle to understand abstract ecosystem concepts and achieve low learning outcomes. This study aims to develop Smart Apps Creator (SAC) multimedia based on CTS for ecosystem topics and to determine its effectiveness in improving students' computational thinking abilities. A Research and Development (R&D) approach using the Lee & Owens model (assessment/analysis, design, development, implementation, evaluation) was employed, involving 36 Grade V students divided into experimental and control groups. Data were collected through observation, interviews, expert validation questionnaires, and pretest-posttest instruments, then analyzed using SPSS 25 with paired sample t-test and independent sample t-test. The multimedia product named "ECO-LAB" was categorized as "Highly Feasible" with feasibility percentages of 100% from the media expert, 93% from the content expert, and 98% from the learning expert. The paired sample t-test showed a significant improvement in the experimental group's average score from 49 to 82 (Sig. = 0.000; $p < 0.05$), while the independent sample t-test revealed a significant difference between the posttest scores of the experimental and control groups (Sig. = 0.013; $p < 0.05$). SAC multimedia based on CTS proved effective in improving Grade V students' computational thinking abilities in ecosystem topics.

Keywords:
Smart Apps Creator; Computational Thinking Skills; Ecosystem; Elementary School

A. INTRODUCTION

The rapid advancement of digital technology has significantly influenced contemporary educational environments, prompting shifts in how students interact with learning materials. While traditional teacher-centered instruction remains a foundational pedagogical approach, recent literature suggests it may be more effective when complemented with interactive strategies to better accommodate diverse learning preferences in the digital era (Rozali et al., 2022). In response to these evolving educational demands, the Merdeka Curriculum was designed to facilitate deeper, more relevant, and student-centered learning experiences, including the strengthening of process and scientific skills in Science and Social Studies (IPAS) (Purnomo et al., 2024). A key 21st-century skill emphasized within this framework is computational thinking (CT), which has been established as a core literacy alongside reading, writing, and arithmetic (Kemendikdasmen, 2025). This skill comprises four foundational pillars: decomposition, pattern recognition, abstraction, and algorithms (Marifah et al., 2022).

Within the Merdeka Curriculum structure, the ecosystem topic in Phase C IPAS is particularly important, as it requires students to investigate the interdependent relationships between biotic and abiotic components and their effects on ecosystem stability

(Kemendikbudristek, 2022). Grade V elementary students are still at the concrete operational stage, making it difficult for them to understand abstract and complex ecosystem concepts without concrete objects or specific visual representations (Qomara et al., 2024). Preliminary observations at MI Al-Fattah Malang revealed that conventional approaches such as lecturing, static images, and student worksheets still dominate ecosystem instruction, with approximately 30% of students scoring below the Minimum Mastery Criteria, despite the school having adequate technology facilities and students being familiar with smartphones.

Smart Apps Creator (SAC) is a multimedia application development tool that enables users to create interactive learning applications without requiring advanced programming skills, featuring the integration of text, images, audio, video, and animation (Bachri & Istianah, 2025; Yallah & Huda, 2022). While integrating computational thinking (CT) into SAC-based multimedia holds the potential to train students in systematic problem-solving, previous studies have largely treated SAC development and CT as isolated domains. For instance, prior research has successfully utilised SAC for topics like temperature and heat with high feasibility scores (Elviana & Julianto, 2022) . but primarily as a digitized presentation tool lacking an explicitly embedded cognitive framework. However, studies that do apply CT, such as in STEM-based science learning (Kristiandari et al., 2023), or animal life cycles (Maulana et al., 2023) have relied on conventional or non-SAC platforms.

Novelty of this study lies in bridging this specific gap by synergizing SAC technology with a CT cognitive framework for elementary ecosystem education. Unlike prior research that either omits explicit CT components in SAC development (Bachri & Istianah, 2025; Elviana & Julianto, 2022; Yallah & Huda, 2022) or treats CT merely as a post-learning assessment metric, this study operationalizes the four CT pillars, decomposition, pattern recognition, abstraction, and algorithms, as the foundational instructional design framework. By systematically mapping these four pillars directly onto the interactive mechanics of "ECO-LAB," this research transforms abstract ecological concepts into concrete computational challenges, offering a distinct methodological breakthrough in digital science pedagogy.

Based on this gap, the present study develops and tests SAC-based multimedia integrated with computational thinking skills for the Grade V ecosystem topic at MI Al-Fattah Malang. The objectives of this study are to describe the procedure for developing SAC multimedia based on CTS for the Grade V ecosystem topic, and to determine the effectiveness of that multimedia in improving students' computational thinking abilities. Effectiveness in this study is indicated by (1) a statistically significant improvement between pretest and posttest scores within the experimental group using a paired sample t-test, and (2) a statistically significant difference between the posttest scores of the experimental and control groups using an independent sample t-test, with the latter serving as the primary basis for the effectiveness claim.

B. METHOD

This study employs a Research and Development (R&D) approach using the Lee & Owens instructional development model, which consists of five stages: assessment/analysis, design, development, implementation, and evaluation (W.Lee & L.Owens, 2004). The model was selected because its systematic stages are appropriate for developing multimedia-based instructional product, with the result of each stage serving as the basis for the subsequent stage in developing the ECO-LAB Multimedia.

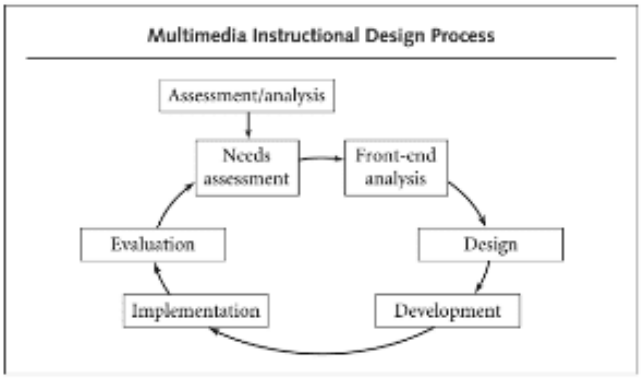


Figure 1. Stages of the Lee & Owens Model

In the assessment/analysis stage, the researcher conducted classroom observations and semi-structured interviews with the Grade V-A and V-B teachers and a sample of students to identify the gap between actual learning conditions in the field and the ideal state. The interviews focused on three themes: the teaching methods and media currently used for the ecosystem topic, students' difficulties in understanding ecosystem concepts, and students' familiarity with digital devices. Observation focused on classroom activities during ecosystem instruction, including the media and teaching strategies used and students' engagement. The results of this needs analysis were then triangulated with audience analysis (students' characteristics and prior digital exposure), technology analysis (availability of school infrastructure such as smartphones/tablets and internet access), media analysis (review of existing ecosystem-topic media), and content analysis (mapping of the Phase C IPAS Learning Outcomes for the ecosystem topic) to establish the basis for the design stage.

The design stage translated the analysis results into a structured plan for ECO-LAB. The researcher organized the Grade V IPAS ecosystem content according to the learning outcomes and objectives and integrated four computational thinking skills: decomposition, pattern recognition, abstraction, and algorithm design. These skills were represented through interactive activities such as classifying ecosystem components, identifying relationships and food webs, selecting relevant information, and arranging solution steps. The researcher also developed the content structure, navigation, interface, storyboard, evaluation items, and research instruments, including expert validation sheets and pretest-posttest instruments.

The development stage transformed the design and storyboard into an Android-based multimedia product using Smart Apps Creator (SAC). ECO-LAB integrated ecosystem content with text, images, audio, video, drag-and-drop activities, line-connecting activities, and quizzes, including interactive tasks representing the four computational thinking skills. The completed product was validated by media, material, and learning experts to assess its suitability. The validators' scores, comments, and suggestions were used to revise the content, media presentation, and learning components before the product was implemented.

Product feasibility was assessed by three experts: a media expert, a material expert, and a learning expert. Data were collected using five-point Likert-scale questionnaires (1 = very poor to 5 = very good). The media expert questionnaire comprised 15 items addressing media and instructional communication, including visual quality, typography, color, illustration, layout, navigation, ease of use, and user engagement, with a maximum score of 75. The material expert questionnaire comprised 20 items addressing content quality, learning-goal alignment, instructional feasibility, and CTS integration, with a maximum score of 100. The learning expert questionnaire comprised 21 items addressing content and pedagogical feasibility, media and learning resources, CTS integration, and evaluation, with a maximum score of 105. The questionnaires were developed based on the study objectives and relevant criteria for evaluating instructional multimedia, and provided space for qualitative comments and suggestions for product revision. The resulting scores were converted into percentages to determine the feasibility level of the ECO-LAB multimedia.

The feasibility level for each validator was calculated using the formula:

$$P = \frac{\sum F}{\sum N} \times 100\%$$

Where:
P = Final score
F = Total score obtained
N = Maximum possible score

The resulting percentages was then converted into a qualitative feasibility category based on the media validity criteria proposed by (Hanifah et al., 2020):

Table 1. Media Validity Criteria

Score	Criteria	Description
90 < Score ≤ 10	Very Valid/Highly Feasible	No revision required
80 < Score ≤ 9	Valid/Feasible	No revision required
70 < Score ≤ 8	Fairly Valid/Fairly Feasible	Partial revision required
60 < Score ≤ 7	Less Valid/Less Feasible	Revision required
Score ≤ 60	Invalid/Not Feasible	Revision required

Product effectiveness was tested through a quasi-experimental design with a non-equivalent control group design, as field conditions did not permit subject randomization. The two available Grade V classes at MI Al-Fattah Malang were used as intact groups, with 18 students from Class V-A as the experimental group and 18 students from Class V-B as the control group. Both classes followed the same curriculum, were taught the ecosystem topic within the same academic term, and had not previously received computational-thinking-based instruction. The two classes were selected as intact groups because school scheduling did not allow individual students to be reassigned between classes; this is a common constraint in quasi-experimental classroom research and is acknowledged as a limitation of this study. The comparability of the two groups' initial ability was examined through their pretest scores (Class V-A: 49; Class V-B: 51), which were close in magnitude, suggesting that the two classes did not differ substantially in their baseline computational thinking ability prior to treatmen. Because the sample was limited to 36 students from two intact classes at a single madrasah, the findings on effectiveness should be generalized with caution to other schools, grade levels, or topics.

C. RESULTS AND DISCUSSION

SAC Multimedia Development Process

In the assessment/analysis stage, the results of observations and interviews revealed that ecosystem instruction at MI Al-Fattah Malang remains teacher-centered and has not trained students' computational thinking skills, despite most students being accustomed to using smartphones. The Grade V-A teacher noted that "students still struggle to remember the material, especially the relationships between components such as food webs," because learning has so far been perceived as insufficiently meaningful.

In the design stage, the content structure was developed based on the IPAS textbook published by the Ministry of Education and Culture on "Harmony in the Ecosystem." The material in this media was arranged progressively from simple to more complex concepts and divided into three subtopics: understanding ecosystems as systems, patterns of interaction within ecosystems, and the impact of human activities. The four CTS components were directly integrated into interactive features, including: (1) decomposition through drag-and-drop activities for classifying biotic and abiotic components; (2) pattern recognition through games identifying symbiosis relationships and cause-and-effect patterns; (3) abstraction through simple visual simulations of ecosystem damage scenarios; and (4) algorithms through the

sequencing of steps for maintaining ecosystem balance.

The development stage produced the ECO-LAB Android application, which consists of an opening page (splash screen), usage instructions, main menu, Learning Outcomes (CP) and Learning Objectives (TP) page, learning materials, CTS challenges for all four components, evaluation, bibliography, and developer profile, incorporating text, images, audio, video, drag-and-drop, line-matching, and evaluation components.



Figure 2. Splash Screen Display



Figure 3. Main Menu Display



Figure 4. Decomposition Integratio



Figure 5. Pattern Recognition Integrat

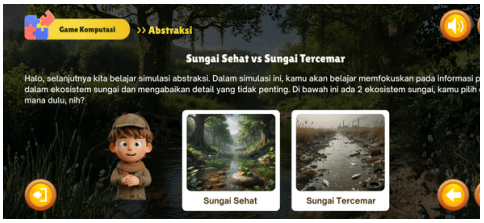


Figure 6. Abstraction Integration

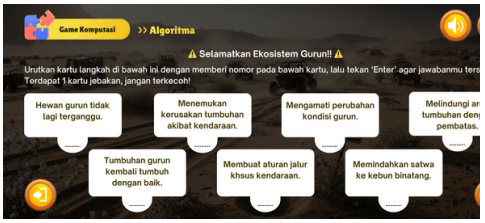


Figure 7. Algorithm Integration

The implementation stage was conducted with 18 Grade V-A students as the experimental group through three steps: administering a pretest, learning with ECO-LAB, and administering a posttest, with 18 Grade V-B students as the comparison group in conventional instruction. The evaluation stage was both formative and summative; formative evaluation resulted in several revisions based on validator recommendations, while summative evaluation showed that the product had a positive impact on students' active engagement and computational thinking abilities.

SAC Multimedia Feasibility

Table 2. Expert Validation Results

Validator	Score	Percentag	Category
Media Expert	75/75	100%	Highly Feasible/Vali
Content Expert	93/100	93%	Highly Feasible/Vali
Learning Expert	103/105	98%	Highly Feasible/Vali

Source: Researcher's Data Processing

In this study, "validity" refers to the extent to which the ecosystem content and CTS constructs accurately represent the intended learning outcomes and theoretical frameworks, whereas "feasibility" denotes the practicality and appropriateness of the ECO-LAB multimedia for actual classroom implementation. To ensure both validity and feasibility, the prototype

underwent a rigorous evaluation process by three credentialed experts. The media validation was conducted by a university lecturer specializing in instructional media innovation; the content validation was performed by a university lecturer with expertise in elementary education; and the pedagogical validation was carried out by a Grade V classroom teacher acting as a learning practitioner.

The validation procedure involved administering structured Likert-scale questionnaires, gathering both quantitative evaluations and qualitative feedback, and conducting iterative revisions, such as adjusting the splash screen and refining the sentence structures, to perfect the product prior to field testing. All three validators categorized the product as "Highly Feasible," as their respective scores consistently exceeded the >90% threshold required for the highest classification. Consequently, the ECO-LAB multimedia was approved for field testing without requiring major structural revisions. The perfect 100% score from the media expert indicates that the visual design, layout, typography, and interactive elements optimally adhere to Mayer's multimedia design principles (Mayer, 2009). Concurrently, the 93% score from the content expert confirms that the ecosystem material is accurate, complete, and perfectly aligned with the Phase C IPAS Learning Outcomes, thereby demonstrating that the four CTS components were successfully integrated into the learning material.

The assessment from the learning expert, who is also the classroom teacher, yielded a score of 98%, indicating that the ECO-LAB application is considered highly helpful in presenting material, interactive games, and evaluation. Nevertheless, the validator identified one technical issue with the essay question feature: the system's inability to detect answer variations beyond the predetermined keywords. This is attributed to the limitations of the Smart Apps Creator platform as a no-code software, which still relies on keyword-matching mechanisms in the essay answer evaluation process.

Revisions were made based on expert validator recommendations, including adding the developer's name and subject on the splash screen, adding category labels to the food chain drag-and-drop feature, simplifying sentences in the first subtopic, and proofreading spelling errors in accordance with PUEBI (Indonesian Standard Spelling). This is consistent with the role of expert review in guiding media revisions prior to implementation (Marisa et al., 2024).

Effectiveness of SAC Multimedia on Computational Thinking Ability

Table 3. Average Pretest-Posttest Scores for Both Groups

Group	Average *Pretest*	Average *Posttest*
Experimental (n = 18)	49	82
Control (n = 18)	51	70

Source: Researcher's Data Processing

Prior to hypothesis testing, the data were subjected to prerequisite tests to satisfy the assumptions of parametric analysis. Normality test results using the Shapiro-Wilk method yielded significance values of 0.080, 0.197, 0.086, and 0.069 across the four data groups, all of which are greater than 0.05 (Sig. > 0.05), confirming that the data are normally distributed. Subsequently, the homogeneity test using Levene's statistic produced a significance value of 0.364. Because this value is strictly greater than 0.05 (Sig. > 0.05), it verifies that the variance between the experimental and control groups is statistically homogeneous. Given that both prerequisite assumptions were fully met, the subsequent independent sample t-test appropriately utilized the "Equal variances assumed" criteria for interpretation.

evidence for the effectiveness of ECO-LAB multimedia comes from the between-group comparison rather than the within-group change alone. The independent sample t-test on posttest scores yielded a significance value of 0.013 ($p < 0.05$, equal variances assumed), indicating a statistically significant difference between the experimental and control groups after treatment. This is an important basis for the effectiveness claim because, as shown in Table 3, the experimental group actually started with a slightly lower average pretest score than the control group (49 versus 51) yet ended with a higher posttest score (82 versus 70); a

within-group improvement alone cannot rule out maturation or repeated-testing effects, whereas the between-group difference controls for these threats to some degree. Calculations derived from the raw test scores reveal an effect size for this between-group comparison of d = 0.88, indicating a large practical effect of the multimedia application on students' computational thinking skills. Furthermore, the paired sample t-test for the experimental group corroborated this internal cognitive growth, demonstrating a significance value of 0.000 ($p < 0.05$) alongside an average score improvement of 32.78 points.

This improvement can be explained through the four CTS pillars integrated into the multimedia and objectively measured through the pretest-posttest instrument. The assessment instrument comprised 10 multiple-choice questions formulated across various cognitive levels of Bloom's Taxonomy (ranging from C1 to C6). The scoring rubric awarded 10 points for each correct answer, resulting in a maximum possible score of 100. Specifically, the four CTS components were operationalized and measured as follows:

First, decomposition was assessed using 2 items (questions 1 and 2) that required students to break down complex ecosystem concepts into simpler biotic and abiotic components, mirroring the application's interactive drag-and-drop categorization activities. Second, pattern recognition was evaluated through 3 items (questions 3, 4, and 5) wherein students identified symbiotic relationships and food chain patterns, aligning with the multimedia's games that trained them to recognize recurring regularities as a foundation for making generalizations. Third, abstraction was measured using 2 items (questions 6 and 7) that prompted students to extract core information from ecosystem damage scenarios while disregarding irrelevant details, a cognitive skill directly practiced during the ECO-LAB simulations. Finally, algorithm design was assessed via 3 items (questions 8, 9, and 10) requiring students to logically sequence steps for maintaining ecosystem balance, reflecting the application's sequencing challenges designed to train systematic, sequential, and logical thinking (Porzak & Psomos, 2023; Wing, 2016).

Conversely, the lower improvement in the control group demonstrates that lecture-based instruction and student worksheets provide insufficient opportunities for students to actively practice the four CTS components, since computational thinking is a cognitive process requiring active and contextual practice rather than mere information transfer (Ardiansyah et al., 2024).

These research findings are consistent with previous studies demonstrating that interactive media based on Smart Apps Creator (SAC) is effective in improving elementary school students' science learning outcomes and conceptual understanding (Bachri & Istianah, 2025; Rukoyah & Bektiningsih, 2024). Additionally, research by (Ningsih et al., 2024) confirmed that interactive media on ecosystem topics received very positive responses from both validators and students.

Nevertheless, this study makes a distinct contribution compared to previous research. Prior studies focused predominantly on the effectiveness of SAC media or the application of the Computational Thinking Skills approach separately, whereas the present study integrates all four CTS components directly into every interactive feature of the ECO-LAB multimedia. The results demonstrate that this integration not only produces a feasible learning medium but also significantly improves students' computational thinking abilities.

Table 4. Comparison of Previous Studies and Current Research

Author(s) & Ye	Focus & Media P	Subject & T	Difference with Current St
(Muhaimin & Zumrotu 2023)	SAC Media Develo	Grade V (Measur	Focuses solely on SAC feasibili not target or integrate CT skills
(Kristiandari et al., 20	CT & STEM Integr	Grade V (Science	Applies CT through a STEM a not via digital interactive SAC me
(Wahyuni et al., 2023)	CT Application in	Grade IV (Leaf Structures)	Uses conventional worksheets rather than digital in applications

(Ningsih et al., 2024)	Interactive PPT M	Grade V (Ecosyst	Utilizes PowerPoint rather th focuses on general learning o not CT
(Satria et al., 2023)	CT Media via Scrat	University Stude (Heat Transfer)	Uses complex block-progr (Scratch) for higher education, u no-code SAC for elementary stud
This Study	SAC Media integrat CT	Grade V (Ecosyst	Synergizes the four CT pillars into interactive SAC features (E for elementary science

Source: Researcher's Data Processing

Islamic Educational Perspective in the Development of ECO-LAB Multimedia

It should be noted that the four CTS components and their interactive features described above were the primary design principles guiding the development of ECO-LAB. Islamic educational values were not formulated as explicit design criteria during the assessment/analysis or design stages, but are discussed here as an interpretive lens through which the completed product can be understood within the context of madrasah-based IPAS learning. As an IPAS learning product, the development of ECO-LAB multimedia also reflects kauniyah values, the signs of Allah's greatness spread throughout the universe (Handayani, 2025). Allah says:

"We will show them Our signs in the horizons and within themselves…"
(QS. Fushshilat: 53)

Pedagogically, the integration of Islamic values in ECO-LAB transcends mere scriptural legitimation by operationalizing tadabbur (guided reflection) through computational thinking activities. Rather than appending verses as an afterthought, the multimedia utilizes CT as the cognitive vehicle for 'ibadah fikriyyah (intellectual worship), where studying natural laws is viewed as observing Allah's creation. QS. Ali Imran verses 190–191 frame the recognition of pattern and order in creation as an invitation for the intellect to contemplate (Hunsouw, 2013). ECO-LAB scaffolds this pedagogical mechanism directly: decomposition and pattern recognition activities provide the structured framework for the orderly observation required for tadabbur, while abstraction and algorithmic sequencing guide students to draw systematic, rather than hasty, conclusions regarding ecosystem preservation. This conceptual alignment is supported by empirical observations gathered during the implementation phase: students who were previously passive exhibited heightened curiosity, active questioning, and sustained engagement when interacting with the ecological simulations. Consequently, while the primary measured outcome was cognitive (CT proficiency), these qualitative behavioral shifts empirically demonstrate that the interactive media successfully fostered the inquisitive and reflective mindset necessary for contemplation within an Islamic educational framework..

D. CONCLUSION

The Smart Apps Creator-based multimedia integrated with computational thinking skills (CTS) for the ecosystem topic, developed using the Lee & Owens model and named ECO-LAB, was validated as "Highly Feasible". The product achieved evaluation scores of 100% from the media expert, 93% from the content expert, and 98% from the learning expert. Furthermore, ECO-LAB proved effective in improving Grade V students' computational thinking abilities. This effectiveness is evidenced by a significant internal improvement within the experimental group, whose average score increased from 49 to 82 (paired sample t-test, $p = 0.000$) and a statistically significant difference between the experimental and control groups' posttest scores (independent sample t-test, $p = 0.013$) yielding a large effect size ($d = 0.91$). These findings affirm that systematically embedding the four CTS components into an interactive, offline-accessible application serves as a robust complement to conventional teacher-centered instruction for abstract science topics like ecosystems.

This study has several limitations: the sample was limited to 36 students from two intact classes at a single madrasah, subjects were not randomly assigned, and the Islamic educational perspective discussed in this study was developed as an interpretive discussion of the completed product rather than as an empirically measured design principle. Accordingly, the findings on effectiveness should not be generalized beyond similar madrasah settings, comparable sample characteristics, and the ecosystem topic without further replication. For classroom teachers, ECO-LAB is recommended as an interactive supplement to teacher-led instruction, utilizing its four CTS challenges as structured practice activities following initial concept introduction, and can draw on the essay feature's current limitations in the application's essay evaluation feature, relying on manual assessments for open-ended questions when necessary. Future research is recommended to improve the essay evaluation feature in SAC, to replicate this study with a larger and more diverse sample using randomized designs where feasible, to report effect sizes alongside significance tests, and to expand the integration of computational thinking skills, together with a more explicitly designed integration of Islamic educational values from the outset, to other IPAS topics or different subjects at the elementary school level.

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