From Digital Tools to Civic Engagement: How the NUSANTARA App Enhances Critical Citizenship Thinking

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***Abstract*—This study aims to examine how the NUSANTARA mobile application can improve students' critical thinking skills in understanding citizenship issues. The background of this study is based on the need for an innovative learning approach that utilizes digital technology to shape reflective citizenship awareness and engagement. The study was conducted in the Pancasila and Civic Education (PPKn) Study Program, Faculty of Teacher Training and Education, Lambung Mangkurat University, in the Wetland Environmental Citizenship Course, using a quasi-experimental design. A total of 60 students were divided into two groups: an experimental group that used the NUSANTARA application and a control group that received conventional learning. For four weeks, the experimental group engaged with a digital citizenship module containing issue scenarios, reflective questions, and interactive media based on local and global contexts. Critical thinking skills were measured using a standardized test designed to assess analytical, evaluative, and reflective skills in the context of citizenship. Additionally, qualitative data were obtained through student reflection journals and focus group discussions. The results showed a significant increase in critical thinking scores in the experimental group compared to the control group. Qualitative data also showed an increase in citizenship awareness, critical questioning skills, and digital participation of students who used the application. This study concludes that the NUSANTARA application is effective in encouraging higher-order thinking skills and active involvement in citizenship learning in higher education.**

***Keywords*—NUSANTARA App, critical thinking, citizenship, learning innovation, digital education**

I. Introduction

The digital revolution has brought about fundamental changes in the way individuals learn, interact, and understand the world around them [1]. Higher education, as a space for forming a generation of critical citizens, is required to adapt to these technological advances, including in the realm of Pancasila and Citizenship Education (PPKn). In this context, citizenship education not only aims to transmit the basic values of national and state life, but also encourages critical thinking skills on public issues such as social justice, environmental sustainability, and civil rights [2]. One approach that is developing in this realm is ecological citizenship education, which integrates environmental awareness into students' civic thinking and actions, especially in dealing with the climate crisis, environmental degradation, and ecological inequality [3].

However, the approach to civics learning in many institutions remains conventional, oriented toward memorization and one-way transmission, which is insufficient to address the challenges of student engagement in complex contemporary issues [4]. To address this challenge, innovative, integrative, and contextual learning media are needed. One solution offered in this research is the development of the NUSANTARA application as an Android-based mobile learning medium. This application includes three main components: an e-book as a reading resource, a learning video as a visualization of concepts, and an audio podcast as a medium for repetition and reflection [5]. All content is designed to build ecological citizenship awareness through issues such as environmental rights, ecological justice, and public participation in natural resource management.

Previous studies have shown that the use of mobile technology in civics learning can significantly increase student participation and critical thinking [6]. Furthermore, the case study-based learning model and interactive approach integrated into the mobile learning platform have been highly appreciated by teachers and subject matter experts [7]. Another study also found that the use of an Android application for civics learning at the high school level facilitates an interactive and values-based learning process [8].

However, most of these studies have not addressed ecological citizenship-based approaches, have not targeted higher education students, and rarely systematically integrate multimodal learning formats. Recent systematic literature reveals that most implementations of digital citizenship education still focus on media literacy, digital norms, and digital rights, while the relationship between civic participation and ecological responsibility remains underexplored [9].

Organizations such as UNESCO emphasize that citizenship in the digital age requires developing critical thinking skills, information literacy, and the ability to responsibly voice citizens' aspirations [10]. Digital citizenship is not merely the technical ability to use technology, but encompasses socio-political understanding and the capacity to use digital spaces for meaningful democratic participation [11]. Therefore, developing digital media based on ecological citizenship is a strategic step in strengthening citizenship education that is contextual, reflective, and adaptive to local and global issues.

Furthermore, the values of national insight also need to be strengthened in application-based citizenship learning, as part of the formation of a national identity that is inclusive and adaptive to cultural diversity and ecological challenges [12]. In this context, the NUSANTARA application is designed not only as a learning tool but also as

a reflective vehicle for developing the character of critical and environmentally conscious citizens.

Technically, the development of this application also responds to the principles of successful mobile learning, namely technological readiness, effective pedagogical design, institutional support, and user readiness [13]. By combining e-book, video, and podcast formats, this application supports multimodal learning that can adapt to various student learning styles. This format aligns with mobile inquiry-based learning approaches such as the Stanford Mobile Inquiry-based Learning Environment (SMILE), which has been shown to enhance higher-order thinking skills through the development of issue-based reflective questions [14].

This research was conducted in the Civics Study Program, Faculty of Teacher Training and Education, Lambung Mangkurat University, using a quasi-experimental approach that combined quantitative methods (pre-test and post-test) with qualitative reflection through journals and group discussions. The selection of this campus as a research location was based on the multicultural character of the students and their origins from the wetland ecosystem environment, which makes it contextual for the development of ecological citizenship learning [15].

In addition, recent studies have indicated that integrating local wisdom and the characteristics of the younger generation into innovative learning models can foster social cohesion and reflective thinking skills regarding identity narratives in the digital space [16]. Therefore, developing applications such as NUSANTARA is important not only for improving students' critical thinking skills but also as a strategy for strengthening a locally based, critical, and adaptable civic identity in the era of digital transformation. However, most research on digital and mobile learning in citizenship education still focuses on digital literacy and democratic participation (Bennett, Wells, & Rank; Sari & Murdiono). Only a few studies specifically integrate ecological citizenship perspectives into mobile app-based learning platforms (Dobson; Barry). Furthermore, most digital citizenship learning initiatives still emphasize general citizenship competencies and fail to link them to contextual environmental issues that directly impact students' local realities. Empirical research targeting university students, particularly in developing country contexts, is also very limited. Multimodal approaches, combining e-books, podcasts, and videos, are rarely systematically applied in this field.

Therefore, this study seeks to fill this gap by developing and testing the NUSANTARA mobile application, an innovative digital platform contextualized within the wetland ecosystem of South Kalimantan, to enhance students' critical thinking skills and ecological citizenship awareness This research differs from previous studies on mobile app-based learning in civic education because it places the local context, the wetland ecosystem of South Kalimantan, at the center of content design. This approach not only integrates digital technology but also links it to students' direct ecological experiences, making it a novel contribution to the development of a locally context-based ecological civic education model.

This research aims to answer two main questions: (1) to what extent can the NUSANTARA application improve students' critical thinking skills in understanding ecological citizenship issues, and (2) how students' experiences using the application shape their understanding of ecological responsibility as part of civic practice. The findings of this study are expected to provide theoretical and practical contributions to the development of locally based digital citizenship education that is relevant and replicable in other higher education institutions.

II. Literature Review

A. Digital Learning

Digital learning is a technology-based approach that emphasizes flexibility, multimodality, and interactivity through the use of digital devices for material delivery, communication, and learning evaluation (Alrasheedi, Capretz and Raza) [17]. According to Garrison and Anderson [18], effective digital learning requires active interaction between educators and students. Meanwhile, Cognitive Load Sweller's theory [19] emphasizes the importance of integrating visuals, text, and audio to deepen understanding. In line with Vygotsky's [20] view, digital technology now functions as a social mediating vehicle for constructing the meaning of learning. Several studies demonstrate the effectiveness of this approach. Rejas *et al*. [21] found that mobile learning can improve students' critical thinking skills. In Indonesia, Cavus and Uzunboylu [22] and O'Reilly *et al*. [23] reported that the use of Google Classroom and locally context-based mobile learning media can strengthen students' analytical skills and ethical literacy. However, Mendes *et al*. [24] and Panyukova *et al*. [25] reported that the use of mobile learning media, particularly Google Classroom, strengthens students' analytical skills and ethical literacy. Panyukova *et al*. [25] warn that digital learning risks reducing focus and effectiveness if not accompanied by adequate pedagogical preparation and digital literacy.

Recent trends indicate a shift from passive learning to participatory models such as the Stanford Mobile Inquiry-Based Learning Environment (SMILE) [26], which encourages students' reflective and collaborative skills. This approach is relevant to citizenship education, as explained by Wallace and Bodzin [27] and Ricoy and Sánchez-Martínez [28], who argue that digital literacy and citizen science-based applications can foster ecological awareness and social responsibility. In this context, the NUSANTARA application is developed as an example of a multimodal digital learning application that integrates e-books, videos, and podcasts to foster reflective ecological citizenship participation.

B. Critical Thinking Learning

Critical thinking skills are one of the key competencies of the 21st century that students need to navigate the complexity of information, make decisions, and actively participate in social, political, and environmental life. Paul and Elder define critical thinking as "the active and skillful intellectual process of conceptualizing, applying, analyzing, synthesizing, and/or evaluating information" to achieve in-depth understanding and make informed decisions [29].

In the context of civics education, particularly those focused on ecological issues, critical thinking plays a crucial role in enabling students to sort information, test arguments,

and develop opinions based on data and responsible civic values. Ennis [30] emphasizes that critical thinking skills do not emerge automatically but rather require training through a systematic and reflective learning approach. Indicators include the ability to identify arguments, explain assumptions, draw logical inferences, and assess the credibility of sources.

Furthermore, Facione, through the Delphi Report Project, identified six main components of critical thinking: interpretation, analysis, evaluation, inference, explanation, and self-regulation [31]. This component serves as the foundation for developing critical thinking-based learning instruments and strategies at various stages of education. In the context of digital learning, strengthening critical thinking can be optimized through problem-based, project-based, and inquiry-based learning approaches that integrate the active and collaborative use of technology.

The integration of digital technology in critical thinking learning has received extensive attention in various studies. According to Arum and Roksa, there is a significant correlation between the intensity of reflective strategy use and the improvement of students' critical thinking skills, compared to conventional learning [32]. In another study, Tay and Lim [33] stated that the application of augmented reality-based mobile learning can increase students' learning motivation and higher-order thinking skills, because interactive learning experiences help them understand abstract concepts more concretely through digital visualization. This finding suggests that critical thinking is not only shaped by cognitive aspects but also supported by affective and contextual dimensions.

Schmitt, Baake, and Kero emphasized that citizenship education in the digital era needs to be transformed by utilizing digital technology in a reflective and critical manner. Integrating digital media into citizenship learning not only broadens students' participation in online public spaces but also strengthens their critical thinking skills regarding social and political issues in the digital world [34]. Meanwhile, research conducted by Ruiz-Rojas, Salvador-Ullauri, and Acosta-Vargas [35] shows that collaborative learning utilizing generative artificial intelligence tools in higher education can strengthen students' critical thinking skills. Through digital collaboration, students are encouraged to evaluate ideas, construct more logical arguments, and develop creative solutions to various academic and social problems.

It is essential to note that critical thinking is not merely an academic skill, but also an expression of civic literacy. Brookfield emphasizes that critical thinking has a liberating function, namely helping individuals become aware of power structures, detect hidden ideologies, and make conscious ethical decisions [36]. Therefore, in the context of ecological citizenship education, critical thinking learning plays a strategic role in developing students' capacity to assess environmental policies, understand the dynamics of climate change, and actively participate as citizens who care about and are responsible for sustainability.

Furthermore, critical thinking is closely related to self-regulated learning, where students are able to monitor their understanding, correct errors in reasoning, and modify their thinking strategies. According to Zimmerman, strengthening metacognitive abilities through independent reflection and the use of adaptive learning technology can gradually deepen critical thinking skills [37]. In this context, the NUSANTARA application plays a strategic role because it provides learning materials in various formats—e-books for conceptual exploration, videos for empirical context, and podcasts for personal reflection, all of which support the development of students' critical thinking skills in ecological citizenship issues.

Thus, critical thinking is an important foundation in 21st-century citizenship education, especially in addressing cross-disciplinary issues such as the environment, democracy, and digital identity. Digital-based learning approaches designed to be interactive and reflective, such as the NUSANTARA application, are a promising means of developing this competency holistically and contextually.

C. Civic Engagement

Civic engagement is a fundamental concept in citizenship education, referring to the active participation of individuals in public life, whether through political, social, or community activities, with the goal of building a just, inclusive, and democratic society. Michael Delli Carpini and Scott Keeter define civic engagement as "the individual and collective actions designed to identify and address issues of public concern" [38]. In education, civic engagement is seen not only as a participatory activity, but as a process of fostering citizens' awareness and responsibility for shared life.

Civic engagement education is rooted in the tradition of deliberative democracy, which emphasizes the importance of citizen participation in public discourse. John Dewey, within his pragmatic philosophical framework, emphasized that democracy is a shared life experience that requires reflective and participatory learning from an early age [39]. Therefore, civic engagement extends beyond voting or protests to include everyday practices such as critical discussion, social problem-solving, and local community organizing. In this context, civic engagement-oriented learning must be designed to foster students' agency as active subjects who are aware of and responsible for the social and ecological conditions around them.

In the last decade, international literature has shown that civic engagement has undergone a significant transformation due to the development of digital technology. Bennett and Segerberg introduced the term "connective action" to describe a new form of technology-mediated civic participation, in which collective identities are formed through digital networks rather than through traditional organizational structures [40]. Social media, participatory applications, and community-based platforms have opened up new spaces for more flexible, interest-based, and often cross-geographical civic engagement. This phenomenon has encouraged the emergence of a more fluid and open civic agency, but also presents new challenges in terms of disinformation, social fragmentation, and shallow engagement.

In an educational context, civic engagement through digital media can be an effective means of developing students' critical thinking skills, empathy, and ecological awareness. According to Kahne and Middaugh, digital-based learning can broaden civic experiences by providing access to diverse information sources, cross-border discussion spaces, and participatory simulations such as digital voting, deliberation

forums, or app-based community action [41]. However, they also caution that digital participation may not necessarily lead to in-depth understanding without critical pedagogical guidance.

In Indonesia, several studies indicate that the implementation of civic engagement in education still faces structural and pedagogical obstacles. Research conducted by Bowyer suggests that citizenship education in the digital age faces challenges in meaningfully integrating digital dimensions into pedagogy and curriculum. He highlighted that learning practices still tend to focus on cognitive aspects and factual knowledge, while student engagement in digital citizenship issues and public participation remains limited [42]. Meanwhile, Cox and O'Loughlin [43] show that podcasts can be an effective means for young people to express their views and strengthen their engagement with environmental issues. Through the production and consumption of digital audio content, students are encouraged to reflect on ecological citizenship values, critically articulate their opinions, and actively participate in social movements related to climate change.

In relation to strengthening civic engagement in an ecological context, recent literature has begun to underscore the importance of integrating citizenship education and environmental awareness. Westheimer and Kahne [44] classify citizenship types into three categories: personally responsible citizens, participatory citizens, and justice-oriented citizens. The justice-oriented model, which emphasizes structural analysis and collective action against social and ecological injustice, is the most relevant framework for shaping transformative civic engagement. This approach is highly suitable for application in issue-based learning, such as climate change, forest destruction, and wetland degradation, issues that are currently highly contextual in the ecological citizenship learning space in Indonesia, particularly South Kalimantan.

Within this framework, the NUSANTARA app is presented as a digital innovation that enhances civic engagement in a more contextual and reflective manner. By presenting material in the form of e-books, local documentary videos, and podcasts featuring student reflections on ecological citizenship issues, this app not only conveys information but also creates a space for critical participation. Students can engage in dialogue, evaluate local policies, and design collective solutions based on digital communities. This model strengthens the argument that civic engagement in the digital age is not only possible but urgently needs to be cultivated within a more meaningful, problem-based higher education context.

D. NUSANTARA Application

Innovation in civic education today demands the development of learning media that are not only pedagogically effective but also contextual and relevant to the challenges of the times. The NUSANTARA application (an acronym for Nurturing Civic Understanding through Ecological Narratives, Audio-visual, Reading and Reflection Application) is a response to this need. Designed as a digital-based learning medium, this application integrates three main components: e-books, learning videos, and audio podcasts to strengthen students' understanding of ecological citizenship issues, particularly in the context of wetland environments in South Kalimantan.

The primary objective of developing this application is to support learning outcomes in the Wetland Environmental Citizenship course, which emphasizes the integration of democratic values, citizen participation, and ecological sustainability within a single civic education framework. This concept aligns with Paulo Freire's idea that education should be a liberating practice that enables students to critically "read the world" and act against ecological injustice [45]. By presenting locally based digital content, the NUSANTARA application avoids abstract learning approaches and instead roots it in students' social and environmental realities. The conceptual structure of the development of the NUSANTARA interactive learning media is shown in Fig. 1. The diagram illustrates the relationship between learning objectives, ecological citizenship content, and the stages of implementation of application-based media. The NUSANTARA application's visualization is shown in the following image.

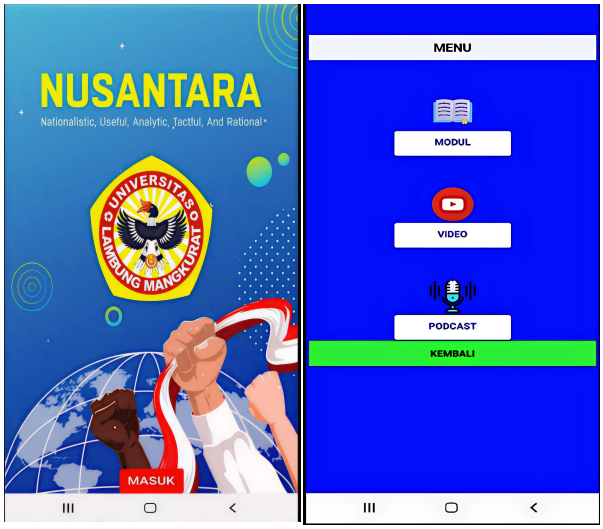

Fig. 1. Display on the NUSANTARA application.

The e-book component of this application contains scientific and cultural narratives about wetland degradation, local biodiversity, and current environmental regulations. These resources are written in a semi-academic style using a contextual storytelling approach. Research by Brigham and McDonald [46] suggests that the process of localizing Open Educational Resources (OPR) to local cultural and social contexts can increase learning relevance and effectiveness. This approach helps students connect the material to real-world experiences in their environment, thereby strengthening their contextual understanding and empathy for local issues, including the environment and sustainability. Meanwhile, the included learning videos feature visual documentation of the ecological conditions of South Kalimantan, interviews with community leaders, and simulations of citizen participation in environmental conservation. According to Mayer, videos with strong verbal and visual integration can enhance meaningful learning through dual coding and multimedia effects [47].

Furthermore, the audio podcast component contains student reflections on ecological citizenship issues they face in their local environment. This format allows the exploration of personal narratives, critical analysis, and the strengthening

of metacognition. Ferguson *et al*. [48] emphasize that podcasts in learning serve as a means of situated reflection that can build students' self-awareness of their social position within the community ecosystem. This is highly relevant in the context of civic learning because it helps students understand their position as active subjects within the broader civic ecosystem.

Pedagogically, the NUSANTARA app is designed to support three key principles of 21st-century learning: multimodality, self-regulated learning, and contextualized civic education. Multimodality allows students to access materials in various formats, visual, audio, and text—thus enriching cognitive processing. The principle of self-regulated learning is facilitated through a self-navigation system, which encourages students to manage their study time, select content according to their interests, and engage in independent reflection. Meanwhile, the local context of the content makes this app powerful in connecting civic knowledge to the realities of life in South Kalimantan, particularly those affected by wetland exploitation, ecological flooding, and water resource degradation.

In practice, the use of this application in the classroom has produced various significant pedagogical effects. Initial studies by the development team showed improvements in students' learning engagement, critical thinking skills, and willingness to voice their opinions on local environmental issues. This aligns with the findings of Yue, Nekmat, and Beta [49], which show that digital literacy developed through digital citizenship practices can encourage more reflective and critical online participation among young people. Through interactions in digital spaces, students learn to express their civic voice more meaningfully and develop the ability to assess social and environmental issues from a contextual perspective.

Furthermore, NUSANTARA can also be interpreted as transformative media because it not only delivers content but also opens up space for student participation and meaning production. Within the social constructivist approach, as developed by Vygotsky, such media acts as a scaffold that enables the zone of proximal development, where students transcend their initial abilities through digital dialogue and interaction [50]. In other words, NUSANTARA not only teaches "what ecological citizenship is," but also "how to become a critical ecological citizen."

By combining digital technology, local context, and a reflective pedagogical approach, the NUSANTARA app, currently in its pilot implementation stage, offers a new model of civic learning that emphasizes students' active involvement in critically understanding social and environmental issues. The app is designed not only to provide easy access and learning flexibility, but also to integrate local values with a global perspective in shaping citizens' ecological awareness. Thus, NUSANTARA serves as a learning medium that is not only relevant to the demands of 21st-century education but also rooted in societal values and environmental sustainability.

III. Materials and Methods

A. Design Research

This study employed a quasi-experimental approach with a non-equivalent control group design. This approach was chosen because it allowed researchers to compare the impact of using the NUSANTARA application on students' critical thinking skills across experimental and control groups, although without full randomization. The study was conducted in the Pancasila and Citizenship Education (PPKn) Study Program, Faculty of Teacher Training and Education, Lambung Mangkurat University, during the even semester of the 2024/2025 academic year.

This study aimed to measure the effectiveness of the NUSANTARA application in improving students' critical thinking skills in understanding ecological citizenship issues. The application consists of three main components: an e-book, learning videos, and audio podcasts, all designed to support the learning outcomes of the "Wetland Environmental Citizenship" course.

The NUSANTARA application is an academic prototype developed specifically for this research and has not been released to the public, but all its main features are fully functional during the learning and research process.

B. Research Subjects

This study involved two established classes, each consisting of 30 students. The researchers were unable to randomly assign students to the groups due to campus limitations. This situation may limit the generalizability of the study results, but the quasi-experimental design employed still provides a meaningful comparison of the effectiveness of the NUSANTARA application. Nevertheless, this approach remains relevant for assessing the impact of learning in a real classroom context, so the results still provide a valid and applicable empirical picture of the application of digital media in civics education.

C. Measurement Instruments and Indicators

The main instruments used in this study were a critical thinking skills test and a student reflection sheet. The critical thinking skills test was designed based on Facione's [51] framework, which includes six critical thinking indicators. The reliability of the critical thinking test instrument was examined using Cronbach's Alpha, which showed a high level of internal consistency ($\alpha > 0.70$). The content validity of the instrument was evaluated by three experts in civic education and learning technology using Aiken's V, and the results indicated acceptable empirical validity ($V > 0.75$). Each indicator is broken down into several essay and short description questions, which are scored on a scale of 1 to 5 based on a performance rubric.

Table 1 presents the critical thinking skills indicators used.

Table 1. Critical thinking skill indicators and measurement descriptions

No	Critical Thinking Ability Indicators	Measurement Description
1	Interpretation	The ability to understand and give meaning to certain data, texts, or situations.
2	Analysis	The ability to break down information into parts to understand their logical relationships.
3	Inference	Ability to draw conclusions based on available evidence or premises.
4	Evaluation	Ability to assess the credibility of sources and the strength of arguments.
5	Explanation	The ability to express thoughts in a coherent and argumentative manner.
6	Self-regulation	The ability to monitor and correct one's own thought processes.

Each indicator was measured using two to three contextually designed questions that convey ecological citizenship issues such as environmental rights, ecological justice, and citizen participation in natural resource management. Student reflections from the experimental group were analyzed to strengthen the quantitative findings and provide an overview of the application-based learning experience.

D. Research Procedures

The research implementation procedure consists of several stages:

1) Students from both groups took a pre-test to measure their critical thinking skills before the treatment.
2) The experimental group participated in four 100-minute sessions of NUSANTARA app-based learning. Meanwhile, the control group employed conventional lecture and discussion methods using printed learning materials.
3) After the intervention was completed, both groups took a post-test identical to the pre-test.
4) In addition, students in the experimental group were asked to write weekly reflections on their experiences using the app and their understanding of ecological citizenship issues.

The research was conducted through four stages, namely: (1) pre-test, (2) implementation of NUSANTARA application-based learning, (3) post-test, and (4) qualitative reflection through journals and FGDs. Reflection journals were collected at the end of each session to document students' learning experiences, while FGDs were conducted to delve deeper into changes in students' understanding of ecological citizenship The experimental group learning was blended, allowing students to access the app content independently outside of class hours and then engage in face-to-face discussions in class to further elaborate on the material. The app's use was flexible and geared toward supporting reflective, locally context-based learning.

E. Data Analysis Techniques

Quantitative data from the pre-test and post-test results were analyzed using two types of statistical tests:

1) The paired sample t-test was used to determine the differences in critical thinking scores in the groups (before and after treatment).
2) The independent sample t-test is used to compare learning outcomes between the experimental and control groups after treatment.

The formula used in the analysis of improving critical thinking skills is as follows:

$$N - Gain = \frac{Skor\ Posttest - Skor\ Pretest}{Skor\ Maximum - Skor\ Pretest}$$

The N-Gain interpretation category refers to Hake's classification. The calculation results are summarized in Table 2.

Qualitative reflection data were analyzed using a thematic approach, categorizing student responses based on themes such as changes in ecological awareness, increased self-reflection, experiences using digital media, and motivation to participate in public issues. The analysis followed the principle of method triangulation validity, which combines objective measurement results with subjective reflective data to ensure that the changes are not merely superficial effects but genuinely reflect a transformation in students' ecological citizenship thinking.

Table 2. N-Gain interpretation and category of critical thinking improvement

Score	Category
$G \geq 0.7$	High
$0.3 \leq G < 0.7$	Medium
$G < 0.3$	Low

To strengthen analytical credibility, the coding process was independently conducted by two researchers. The level of agreement between coders was assessed using Cohen's Kappa ($\kappa = 0.82$), indicating high inter-rater reliability

IV. Result and Discussion

A. What Extent can the NUSANTARA Application Improve Students' Critical Thinking Skills in Understanding Ecological Citizenship Issues?

This study aims to discover the effectiveness of using the NUSANTARA application as a digital learning medium in enhancing students' critical thinking skills in the context of the Wetlands Environmental Citizenship course. The primary focus of this study is to determine the extent to which the use of multimodal-based applications, including e-books, learning videos, and audio podcasts, can have a significant impact on improving higher-order thinking skills, particularly in understanding and analyzing ecological citizenship issues. Data collection was conducted using a critical thinking test instrument administered in two stages: before the learning intervention (pre-test) and after the intervention (post-test), to both the control and experimental groups, to identify changes in learning outcomes.

This study involved two groups of students from the Pancasila and Citizenship Education (PPKn) Study Program at Lambung Mangkurat University who had taken the Wetlands Environmental Citizenship course. The first group, the experimental group, participated in learning using the NUSANTARA application as the primary medium. Meanwhile, the second group, the control group, continued to use conventional learning media, such as text-based teaching materials, classroom discussions, and written assignments. To measure critical thinking skills, an instrument was used based on indicators developed by Ennis and Facione, encompassing interpretation, analysis, evaluation, inference, explanation, and self-regulation. The instrument was validated by experts for its content and empirically validated for reliability through a pilot test. Data collection involved administering pre- and post-tests to each group to obtain quantitative data on changes in critical thinking scores. The results were then analyzed descriptively and presented in Table 3.

The results of the comparison of the increase in critical thinking skills between the experimental group and the control group are visualized in Fig. 2. The graph shows that the average post-test score of the experimental group increased significantly compared to the control group, indicating the effectiveness of using the NUSANTARA application in supporting the development of students'

critical thinking skills. These results indicate that both groups had the same initial (pre-test) score of 64.06. However, a significant difference was observed in the post-test, with the experimental group experiencing a 15.33-point increase, significantly surpassing the control group's 3.83-point increase. The difference in gain scores between the groups was quite striking and strongly indicates the effectiveness of the NUSANTARA app-based learning intervention. The relatively low standard deviation also indicates consistent improvement across participants.

Table 3. Descriptive statistics of pre- and post-test critical thinking scores (experimental vs. control groups)

Group	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Gain Score Mean	Gain Score SD
Experiment	64.06	4.50	79.39	4.66	15.33	6.15
Control	64.06	4.96	67.90	4.54	3.83	7.19

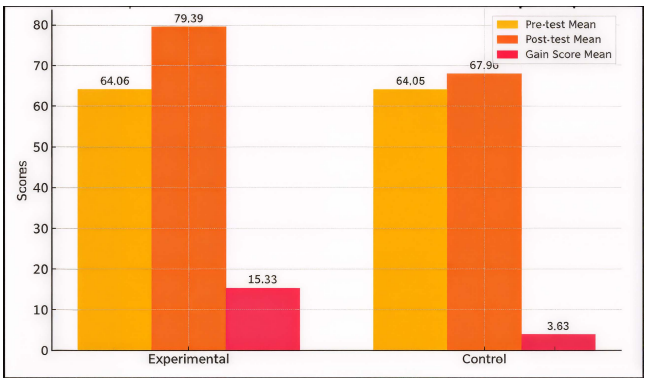

Fig. 2. Critical thinking ability measurement results.

To ensure comparative validity, normality and homogeneity tests were conducted on the post-test data. The normality test was used to determine whether the data were normally distributed, while the homogeneity test was used to determine whether the variances between the groups were equal.

Table 4. Post-test data normality and homogeneity test

Group	df	Sig. Normalitas	Levene Statistic	df	Sig. Homogenitas
Experiment	23	0.057	-	-	-
Control	21	0.074	2.73	42	0.10

The differences in critical thinking skills between the experimental and control groups can be seen in detail in Table 4. The data shows that the average post-test score for the experimental group was higher than that of the control group. This indicates that the use of the NUSANTARA application has a significant influence on improving students' critical thinking skills. The significance value of the normality test for the experimental group was 0.057, and for the control group was 0.074. Both are greater than 0.05, so it can be concluded that the data is normally distributed. Meanwhile, the significance value of Levene's homogeneity test is 0.10, which is also greater than 0.05, indicating that the data variance between groups is homogeneous. These two conditions allow the use of the t-test as an inferential test to determine significant differences between two groups.

Table 5. Independent t-test results for post-test scorest

Group	N	Mean	SD	Sig. (2-tailed)	t hitung	ttabel
Experiment	23	79.39	4.66	0.000	8.211	2.015
Control	21	67.90	4.54	-	-	-

Comparison of the independent t-test results for the post-test scores of the experimental group and the control group are shown in Table 5. The data provides an overview of the differences in the increase in critical thinking skills between the two groups after the learning process using the NUSANTARA application. The t-test yielded a calculated t-value of 8.211, significantly exceeding the t-table value of 2.015 at a 5 percent significance level. The two-tailed significance value was 0.000, less than 0.05, thus rejecting the null hypothesis stating no difference between the two groups.

The interpretation of the results of this study indicates that the NUSANTARA application serves not only as a means of delivering learning materials digitally but has also developed into a pedagogical instrument capable of facilitating active student engagement in a meaningful learning process. In addition to providing multimodal content such as e-books, videos, and podcasts, the NUSANTARA app also builds a reflective learning environment that links ecological citizenship values to students' real-life experiences. Through an approach based on local narratives and concrete visualizations, students are encouraged to consider environmental issues as not merely abstract concepts, but something tangible and closely related to their social context. This supports the constructivist theory's view that effective learning occurs when students engage personally and contextually in constructing meaning from what they learn. Academic literacy in the realm of citizenship is no longer limited to memorizing norms and theories, but rather develops into the practice of reflective and critical thinking about the surrounding social and ecological conditions.

Furthermore, the high and statistically significant difference in scores between the experimental and control groups confirms that the NUSANTARA application has a significant contribution to improving the quality of the learning process. The experimental group using the multimodal application experienced significantly greater improvement in critical thinking skills than the control group using a conventional approach. This demonstrates that the integration of various media forms—narrative text, video documentation, and audio reflections—can stimulate students' diverse cognitive pathways, enriching their information processing. Furthermore, the presence of local context in each material presented helps students build stronger connections between theory and the real-world situations they experience, ultimately deepening their understanding and enhancing their ability to evaluate arguments, analyze policies, and make decisions based on data and values. This contextual factor is an important element that is often overlooked in learning design, even though it is actually a bridge between the academic world and students' social reality.

Thus, the findings of this study not only provide empirical

evidence for the effectiveness of the NUSANTARA application as an educational technology innovation but also strengthen the argument that learning media consciously designed to integrate local context, personal reflection, and multimodality of content have very high pedagogical power. This application is not only a teaching aid but has become a learning platform capable of supporting the achievement of 21st-century competencies, particularly in terms of strengthening critical thinking skills, developing civic awareness, and actively engaging students in ecological issues relevant to their lives. Therefore, an approach such as that offered by the NUSANTARA application needs to be considered as a learning model that is not only adaptive to technological developments but also transformative in forming citizens who are aware, critical, and responsible for environmental sustainability.

Overall, the analysis results indicate that the use of the NUSANTARA application has a significant positive impact on the development of students' critical thinking skills. The integration of various digital content, such as text, videos, and podcasts, can stimulate higher-order thinking skills, reflection, and contextual analysis of ecological citizenship issues. These findings confirm that digital learning designed with a contextual and reflective approach can improve the quality of citizenship learning outcomes while encouraging more participatory and critical citizenship practices. The primary contribution of this research lies in the application of digital learning in a local context, namely the wetland ecosystem of South Kalimantan. This approach demonstrates how environmental issues close to students' lives can be an effective means of fostering ecological citizenship awareness.

B. Students' Experiences in Using the NUSANTARA Application Shape Their Understanding of Ecological Responsibility as Part of Citizenship Practice

The second research question in this study aims to explore in-depth students' experiences using the NUSANTARA app during the learning process of the Wetland Environmental Citizenship course in the Civics Study Program, Faculty of Teacher Training and Education, Lambung Mangkurat University. The approach used to answer this question is a reflective qualitative one, with primary data derived from students' reflection journals, Focus Group Discussion (FGD) results, and audio excerpts from podcasts they created as part of a formative assessment. This study not only seeks to understand how students utilize the app but also how this digital interaction influences the way the students think, feel, and act on ecological citizenship issues, particularly in the context of the wetlands of South Kalimantan, where they live and study.

The qualitative findings indicate that students experienced a very different learning experience compared to previous Civics lessons, which tended to be cognitive and memorization-based. The NUSANTARA app presents content in the form of local e-book narratives, documentary videos about peatland degradation and annual flooding, and reflective podcasts that encourage students to record their personal thoughts on ecological citizenship issues. Students noted that this presentation format fostered emotional and cognitive connections with the socio-ecological realities around them. For example, a student from North Hulu Sungai stated that he realized the importance of swamp rehabilitation and water management after watching a video of post-harvest land damage in a neighboring village. He wrote in his journal that, "I used to think flooding was just a natural occurrence, but now I see that there are policies, choices, and the role of citizens in maintaining ecosystem balance."

Other reflections suggested that integration of local issues into the NUSANTARA content helped students develop ecological awareness as part of their civic identity. In focus group discussions, students expressed that the use of local language, images of familiar places, and interviews with community leaders in the videos made them feel "personally addressed" by the learning material. This demonstrates the important role of contextualization of content in building personal relevance between students and environmental issues. The concept of "place-based civic education" is clearly perceived in this case, where students become not only learners but also active citizens who feel involved in environmental affairs in their own communities.

Furthermore, the use of podcasts as a medium for reflection has proven to provide ample space for autonomous expression. Students are free to record opinions, concerns, and policy proposals in narrative form. From the 25 podcast recordings analyzed, narrative patterns emerged that demonstrate the development of an ecological civic voice. Students began discussing the need for community-based waste management, the importance of environmental education in villages, and even proposing that the village government draft regulations prohibiting the conversion of wetlands into residential areas. This experience reflects the integration of digital civic engagement and ecological citizenship, where students actively position themselves as part of the solution to local environmental issues.

Moreover, themes of self-awareness and empowerment also emerged from the reflective data. Students noted that through the NUSANTARA app, they not only learned about the concepts of participation or ecological justice theoretically, but also began to map out how they themselves could contribute. One student wrote, "I used to think environmental problems were the government's responsibility, but now I realize I am also part of the environment, and I can start with small actions at home." This kind of transformation in awareness is impossible to achieve through lectures or textbooks alone; Learning media that opens up spaces for affective reflection are needed, and NUSANTARA has proven to facilitate this.

The use of the NUSANTARA application as a learning medium in the Wetlands Environmental Citizenship course provides a learning experience that is not only informative but also transformative for students. The learning process, presented through a combination of locally based e-books, environmental documentary videos, and reflective podcasts, elicited multidimensional responses captured in student reflections and group discussions. From the qualitative data analysis, five broad categories of experiences were identified that illustrate the learning transformations experienced by students:

1) Locally-based ecological awareness among students. Students demonstrated increased awareness of environmental issues around them, particularly those related to wetland degradation, local climate change, and

seasonal flooding in South Kalimantan. In-app documentary videos showing the actual conditions in their own areas evoked both shock and strong concern. Many students wrote that they now understand that environmental degradation is not just a national or global issue, but is very real in their villages. The use of local narratives in the e-book, such as the story of farmers who lost their livelihoods due to the conversion of swamps, strengthened students' emotional connection to the content, fostering a place-based ecological awareness

2) Students are becoming increasingly critical of environmental policies and public issues. Through in-app modules that discuss environmental regulations, citizen participation in policy oversight, and analysis of local cases, students are encouraged to evaluate policies in their areas. In a podcast they produced, students openly criticized the weak implementation of the Regional Regulation on swamp ecosystem protection and highlighted the lack of citizen participation in the policy-making process. This process demonstrates that the app is not merely a passive learning tool but also provides a space for students to develop critical and purposeful policy literacy skills.
3) Emotional engagement with the impact of ecological damage. Visual content in the form of documentary videos is a crucial element in triggering students' emotional engagement. Many of them reported feeling sad, angry, or frustrated after witnessing firsthand the impacts of illegal land clearing or river water pollution displayed in the app. This emotional engagement then triggered in-depth reflection, as reflected in the students' reflective journal entries. Several students wrote that they felt a personal responsibility to overcome apathy and to take small actions at home, such as sorting waste and avoiding single-use plastics. This is also supported by Banjarmasin City's regional policy that prohibits the use of plastic in minimarkets.
4) The emergence of a desire to participate in environmental social action. From narrative exploration in podcasts and FGDs, students emerged with ideas and a real commitment to get involved in socio-environmental activities. Several students took the initiative to develop a digital campaign program through social media regarding the dangers of peatland burning. Others expressed a desire to form environmentally conscious communities in their respective villages. This phenomenon demonstrates that learning mediated by the NUSANTARA application not only stops at knowledge and awareness but also moves toward active participation in community life. This aligns with the goal of civic education, which not only produces citizens who are aware of their rights and obligations but also those who act on social values and responsibilities.
5) The formation of a citizen identity that is adaptive and reflective of environmental challenges. The NUSANTARA application, with its learning structure that prioritizes reflection, local narratives, and personal expression through podcasts, has become a safe space for students to develop a more conscious and reflective citizen identity. Students understand not only their role as learners, but also as young citizens living in a situation of ecological crisis and being required to take action. This identity emerges through personal statements such as: "I can't just stay silent," "I have a role, even if small," or "I want to be a teacher who cares about the environment." This identity is not formed instantly, but rather through a multimodal and participatory learning process that provides space for connecting knowledge with everyday life experiences.

Overall, these five categories suggest that students' experiences using the NUSANTARA app extend beyond cognitive aspects and into affective, social, and ethical dimensions. The learning process becomes an experience that shapes awareness, value orientations, and adaptive citizenship practices in response to environmental challenges. This type of learning is relevant to critical pedagogy and problem-based citizenship education approaches. These findings align with Mezirow's view of transformative learning, namely learning that produces changes in an individual's mindset and value orientations through critical reflection on experiences [52]. The NUSANTARA app, in this context, has proven to be not only a learning tool but also a digital learning ecosystem that shapes the character and engagement of young citizens in sustainable development.

These five themes demonstrate that the use of the NUSANTARA app changes not only the way students learn but also how they view themselves as citizens in an era of ecological crisis. Using Vygotsky's social constructivism approach, this learning experience serves as a zone of proximal development, enabling students to advance to higher levels of understanding and participation through digital media-based guidance [53]. This process also aligns with the principles of critical pedagogy introduced by Paulo Freire, which states that education should help students understand their realities and take action to change them [54].

This type of contextual digital learning supports Jenkins and colleagues' findings on participatory culture, where technology enables young people not only to access information but also to produce meaning, participate in public discourse, and build solidarity through digital spaces [55]. Within this framework, NUSANTARA becomes an essential medium for building a locally based civic identity and ecological awareness. This medium provides not only individual learning space but also collective learning, as it allows students to connect directly with the issues experienced by their communities.

Thus, the results of the discussion of the second research question indicate that the learning experience through the NUSANTARA application has shaped students' holistic understanding of their ecological responsibilities as citizens. Learning is no longer simply about knowledge, but rather a reflective and transformative process that triggers empathy, critical awareness, and the drive to realize. Within this framework, the NUSANTARA application serves not only as a learning medium but also as a contextual, dialogical, and ecological means of civic formation. These findings also contribute to the discourse on digital citizenship education, which focuses on character building and concrete action in addressing global and local environmental crises [56].

The results indicate that the use of the NUSANTARA application has a significant impact on enhancing students' critical thinking skills and fostering ecological citizenship awareness based on contextual digital experiences. These

findings reflect the effectiveness of multimodal digital media innovation in strengthening the quality of learning processes and outcomes in civic education focused on environmental issues.

The significant increase in critical thinking skills in the experimental group, with an average score gain of 15.33 points compared to the control group's 3.83 points, demonstrates the real effectiveness of the NUSANTARA application-based learning approach. These results support Facione's theory that critical thinking is the ability to interpret, analyze, evaluate, and draw rational conclusions in complex contexts [15]. The NUSANTARA application, through the integration of e-books, videos, and podcasts, successfully creates a learning environment that enables students to explore civic issues in depth, thereby strengthening higher-order thinking skills.

From a constructivist perspective, learning through NUSANTARA strengthens digital scaffolding, which allows students to remain in the Zone of Proximal Development (ZPD), as described by Vygotsky. Digital media functions as an extension of social interaction, encouraging the reflective and collaborative processes essential to meaning-making [57]. Students not only receive information but also construct their own understanding of complex public issues, such as climate change and local environmental degradation.

Furthermore, findings from the second research question highlight that the NUSANTARA application impacts not only cognitive aspects, but also affective and ethical ones. Students' learning experiences demonstrate transformations in five dimensions: locally based ecological awareness, critical understanding of public policy, emotional engagement with environmental issues, encouragement to participate in socio-ecological action, and the formation of a reflective civic identity. This learning process aligns with the critical pedagogy approach, which positions students as active subjects in dismantling social and ecological inequalities [58].

In the theory of place-based education, as developed by Sobel, the local context plays a crucial role in building students' emotional connection to the issues being studied [59]. NUSANTARA implements this principle by presenting content directly related to the wetland ecosystems of South Kalimantan, home to the majority of respondents in this study. This contextual approach has been shown to increase students' relevance, depth of understanding, and participatory motivation.

Students stated that the use of documentary videos and reflective podcasts raised their awareness of environmental damage that had previously been considered commonplace. This emotional engagement creates an important internalization effect in civic character education. This supports Westheimer and Kahne's view that categorizes citizenship into three types: personally responsible, participatory, and justice-oriented citizens. The NUSANTARA app helps students shift toward the third type, which is critical and advocative [28].

Student reflection data also reveal that the app serves as a vehicle for strengthening civic identity that is adaptive to global challenges, particularly the climate crisis. Within the framework of digital civic engagement theory, as proposed by Rheingold and Jenkins, interactive and open digital platforms provide space for young citizens to independently shape their narratives and social actions [60]. The NUSANTARA app conceptually and technically addresses this need by providing a narrative space that captures and validates students' voices as citizens who think and act ecologically. One student wrote, "Through the podcast about peatlands, I began to think that protecting the environment is not only the government's responsibility, but also a personal responsibility as a citizen."

This quote demonstrates the formation of ecological citizenship reflections through digital media-based learning experiences. Pedagogically, these results demonstrate that digital-based learning is not sufficient if it is merely informative. Digital media must be able to activate the reflective, social, and affective dimensions of learning. This finding aligns with Kolb's experiential learning theory, which emphasizes that effective learning occurs when students actively experience, reflect, conceptualize, and experiment within the learning cycle [61].

Finally, these findings contribute to the literature on digital and ecological citizenship education, particularly in the Indonesian context, which faces serious environmental challenges and socio-cultural diversity. The NUSANTARA application can be positioned as an innovative model in designing locality-based digital learning media, which functions not only as assistive technology but also as a pedagogical ecology that shapes the awareness and engagement of future citizens. The findings of this study also have practical implications for the development of citizenship curricula in higher education, particularly in integrating digital literacy and environmental issues as part of 21st-century citizenship competencies.

Although the results show significant improvements in critical thinking skills and ecological citizenship awareness, this study has limitations in terms of sample size and context. Participants consisted of only 60 students from the same two grade groups, so the results cannot be generalized to a broader population. However, the researchers believe this study can contribute to the application of technology in developing critical and environmentally conscious citizens. The learning intervention lasted four weeks, so the results still reflect a short-term impact on students' critical thinking skills and ecological citizenship awareness. Nevertheless, these findings provide a strong initial picture of the NUSANTARA app's potential in shaping students' reflective and participatory thinking patterns. Further research with a longer implementation period is expected to strengthen these findings and assess the app's influence on actual citizenship behavior outside the classroom context.

V. Conclusion

This study demonstrates that the use of the NUSANTARA app effectively supports the development of students' critical thinking skills and ecological citizenship awareness. The integration of e-books, videos, and podcasts into a single digital platform deepens understanding and encourages reflection on environmental and civic issues. In addition to cognitive gains, the learning experience also demonstrates affective and social transformation, with students demonstrating emotional engagement and increased awareness of participating in real, environmentally conscious

actions. In the long term, the digital citizenship engagement developed through the NUSANTARA app is expected to extend beyond academic contexts. The reflective and collaborative experiences facilitated through this application's digital media will encourage students to transition seamlessly into active real-world participation, from social activities and public discussions to concrete environmental advocacy. Ultimately, this approach ensures that strengthening critical thinking skills and ecological awareness in the classroom directly translates into meaningful actions within the community.

Overall, the NUSANTARA app serves not only as a digital learning tool but also as a participatory learning ecosystem that fosters reflective and environmentally conscious citizenship. Future research is recommended to expand the app's application to other social contexts and examine its long-term impact on students' civic engagement.

Going forward, the implementation of the NUSANTARA app has the potential to have a long-term impact on shaping ecological citizenship behavior in the community. The reflective and collaborative experiences developed within this platform are expected to foster students' participatory habits in public and environmental issues beyond the academic context.

Furthermore, the NUSANTARA app-based learning model has broad potential for development across various educational levels and contexts. At the secondary level, e-book and video features can be simplified to strengthen students' basic critical thinking skills in understanding social and environmental issues. In higher education, a reflective approach through podcasts can be expanded to encourage student research on citizen participation and ecological justice. Beyond the school context, this model can also be adapted for community training or community education, for example, to educate citizens about waste management, disaster mitigation, or environmental advocacy through digital media. NUSANTARA's multimodal approach, which combines text, visuals, and audio, provides high flexibility to adapt to the learners' personal traits, technological capabilities, and local contexts of each region.

With appropriate content and language adaptations, this model will be prospectively administered in international educational institutions focused on ecological citizenship education and sustainable digital participation. On the whole, NUSANTARA is not only a local innovation but also a replicable model for digital citizenship learning that contributes to global efforts to build cross-cultural ecological awareness.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

D.A.N. designed and implemented the entire research process, from design development, intervention implementation, data collection, to analysis of results and writing of the article. M.M. provided conceptual and methodological guidance in the development of research instruments and ensured technical feasibility during the study. E.K. and A.A. conducted a critical review of the findings and the structure of the article and made significant contributions to strengthening the academic argumentation and developing the discussion. All authors were actively involved in the manuscript development process and approved the final version of the article submitted for publication.

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