

DEVELOPMENT OF ECOLOGICAL CITIZENSHIP BASED DIGITAL LEARNING MEDIA TO INCREASE STUDENTS' ENVIRONMENTAL AWARENESS

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Abstract. This study aims to develop ecological citizenship-based digital learning media to increase students' environmental awareness in Pancasila Education subjects. The study used the Research and Development (R&D) method with the ADDIE model which includes the stages of analysis, design, development, implementation, and evaluation. Product validation was carried out by material experts, media experts, and language experts using a Likert scale instrument, while data analysis was carried out descriptively quantitatively. The results showed that the developed media obtained an average validation score of 4.58 or 91.6%, with the Very Feasible category. The content feasibility aspect obtained a percentage of 96.2%, presentation 90.0%, language 92.0%, graphics 100%, and the application of ecological citizenship-based media 80.0%. These results indicate that the media has met the feasibility standards in terms of content, design, language, and visual aspects so that it is suitable for use in learning. Ecological citizenship-based digital learning media is expected to be a learning innovation that supports strengthening environmental awareness and the formation of citizens who are responsible for environmental sustainability.

Keywords: ecological citizenship, digital learning media, environmental awareness.

I. INTRODUCTION

Climate change, environmental degradation, pollution, reduced biodiversity, and increasing waste volumes are increasingly complex global challenges that require the involvement of all elements of society. The Intergovernmental Panel on Climate Change (IPCC) report confirms that human activity is the primary cause of global warming, impacting various aspects of life, from food security and health to social and economic stability [1]. In line with this, the United Nations, through the Sustainable Development Goals (SDGs), specifically Goal 4 (Quality Education), Goal 13 (Climate Action), and Goal 15 (Life on Land), positions education as a strategic instrument in building a society that cares about and is responsible for environmental sustainability [2].

Indonesia faces equally serious environmental challenges. Issues such as suboptimal waste management, river pollution, deforestation, flooding, forest fires, and declining environmental quality demonstrate that sustainable development still faces numerous obstacles. Data from the Ministry of Environment and the Central Statistics Agency (BPS) show that national waste production continues to increase in line with population growth and urbanization,

while recycling rates remain relatively low. This situation indicates that environmental problems are not merely technical issues, but also related to low ecological awareness and citizen responsibility towards the environment [3].

Ecological citizenship has developed as a citizenship paradigm that emphasizes not only the rights and obligations of citizens in the political sphere but also moral responsibility for environmental sustainability [4],[5]. From this perspective, citizens are required to have knowledge, concern, decision-making skills, and active participation in resolving environmental issues. In Indonesia, strengthening ecological citizenship is highly relevant to Pancasila Education because the values of mutual cooperation, social justice, responsibility, and environmental sustainability are part of the implementation of Pancasila values in community life [6],[7].

The development of digital technology provides opportunities to create more interactive and contextual learning. The use of digital learning media can increase learning motivation, student engagement, digital literacy, and critical thinking skills in solving real-world problems [8],[9]. In the context of education, various studies show that students' knowledge of environmental issues is not always followed by tangible changes in attitudes and behavior. Environmental

learning in schools is still dominated by theoretical concepts, thus failing to develop sustainable habits, participation, and ecological responsibility. As a result, students understand the importance of environmental protection but are unable to consistently implement environmentally friendly behaviors in their daily lives. This situation indicates a gap between the cognitive, affective, and psychomotor aspects of environmental education [10].

One emerging approach in Civic Education studies is ecological citizenship. This concept views every citizen as having both the right and the moral obligation to preserve the environment as part of their social responsibility to current and future generations. Ecological citizenship not only emphasizes compliance with environmental regulations but also encourages awareness, active participation, responsibility, ecological justice, and the ability to make decisions that support sustainability. Thus, ecological citizenship has become an important paradigm in developing the character of citizens who care about the environment and are able to contribute to solving various ecological problems [11].

In Indonesia, strengthening ecological citizenship is highly relevant to the goals of Pancasila Education. The values of Pancasila, particularly mutual cooperation, social justice, humanity, and responsibility for the common good, constitute the philosophical foundation that supports the development of students' ecological behavior. Pancasila education not only aims to develop democratic and character-based citizens but also to foster active participation in maintaining environmental sustainability as part of civic responsibility. Therefore, integrating ecological citizenship into learning is one strategy for strengthening both character dimensions and 21st-century competencies. The development of digital technology opens up new opportunities for creating more interactive, contextual, and student-centered learning. The use of digital learning media allows for the presentation of material through interactive videos, animations, simulations, educational games (gamification), augmented reality, infographics, and digital assessments, all of which can increase student motivation and engagement [12]. Compared to conventional media, digital media provides a more authentic learning experience because students can explore various environmental phenomena visually and interactively, thus facilitating the internalization of ecological citizenship values.

Various studies in the last five years have shown that the use of digital learning media contributes positively to improving learning outcomes, critical thinking skills, environmental literacy, and student engagement in the learning process. A systematic review by Hajj-Hassan et al. [13] shows that various digital media, such as virtual reality, augmented reality, interactive multimedia, and e-learning, consistently improve students' understanding of environmental issues while fostering sustainability awareness. Research by Azizah [14] also shows that the use of digital technology in environmental education can increase student engagement, understanding of environmental issues, and support the achievement of sustainable development goals (SDGs). In addition, Husamah et al. [15] through a systematic

literature review confirmed that the integration of digital technology in environmental education has a positive impact on pro-environmental behavior, environmental literacy, and active participation of students in sustainability-based learning. Recent research shows that digital learning media based on Pancasila Education can improve students' ecological competence and environmental awareness. Civics Ecology media, which utilizes augmented reality technology, has been shown to significantly increase students' ecological competence and interest in learning [16]. Furthermore, the use of digital games in Pancasila Education learning has been shown to build students' ecological awareness and support the achievement of sustainable development goals [17].

However, a literature review shows that most research focuses on improving learning outcomes or digital literacy. Research specifically developing ecological citizenship-based digital learning media to increase students' environmental awareness in Pancasila Education is still very limited [18]. Nevertheless, a review of previous research indicates that most digital learning media development still focuses on improving cognitive learning outcomes, digital literacy, or critical thinking skills. Research specifically developing ecological citizenship-based digital learning media is still relatively limited, especially in the context of Pancasila Education in Indonesia. Furthermore, most developed media have not systematically integrated the dimensions of ecological knowledge, moral responsibility, social participation, and concrete actions in environmental protection as a unified civic competency. Therefore, there remains a research gap that needs to be filled by developing learning media that not only enhance knowledge but also shape students' ecological attitudes and behaviors.

Therefore, this study develops ecological citizenship-based digital learning media that integrates ecological knowledge, moral responsibility, citizen participation, and concrete actions in environmental protection. This media development is expected to increase students' environmental awareness while strengthening the character of sustainable citizens. Based on these conditions, this study offers a novelty in the form of developing ecological citizenship-based digital learning media that is systematically designed using a research and development approach. The developed media integrates ecological citizenship principles into Pancasila Education materials through interactive multimedia features, environmental case studies, decision-making simulations, environmental action projects, value reflections, and problem-solving-based evaluations. This approach is expected to provide a more meaningful learning experience so that students not only understand environmental concepts but also develop awareness, responsibility, and commitment to implementing environmentally friendly behaviors in their daily lives.

This research aims to: (1) develop ecological citizenship-based digital learning media suitable for use in Pancasila Education; (2) analyze the media's suitability based on validation by subject matter experts, media experts, and user responses; and (3) test the media's effectiveness in increasing students' environmental awareness. The research results are expected to provide theoretical contributions to the

development of ecological citizenship studies in Pancasila Education, while also providing practical innovations for teachers in implementing learning that adapts to technological developments and the challenges of environmental sustainability in the 21st century.

II. RESEARCH METHODOLOGY

This study used the Research and Development (R&D) method with the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. The ADDIE model was chosen because it has systematic, flexible stages, and is suitable for developing digital learning media oriented towards improving the quality of learning processes and outcomes. This model has been widely used in the development of learning multimedia because it is able to produce valid, practical, and effective products through a continuous evaluation process [19]. The research was conducted at Madrasah Aliyah Nurul Huda in Depok City during the odd semester of the 2026/2027 academic year. The research subjects consisted of 36 students, two Pancasila Education teachers as media users, two Pancasila Education material experts, and two learning media experts. Subjects were selected using a purposive sampling technique, selecting respondents deemed to have characteristics consistent with the research objectives.

The research procedure followed the five stages of the ADDIE model as follows. The first stage of analysis aims to identify learning needs through classroom observations, teacher interviews, student characteristics analysis, curriculum analysis, and Pancasila Education materials related to environmental issues and ecological citizenship. The results of the analysis are used as a basis for determining the competencies, indicators, materials, and features of the digital learning media to be developed. This stage also includes identifying technological needs and user readiness for digital media implementation [20].

The second stage is Design. At this stage, a product design is developed, consisting of storyboards, flowcharts, user interface designs, navigation structures, learning materials, assessment instruments, and ecological citizenship-based learning activity scenarios. The media is designed to include interactive materials, learning videos, infographics, digital quizzes, environmental case studies, eco-action projects, and learning reflections, thereby developing students' knowledge, attitudes, and participation in environmental protection.

The third stage of development involves building digital learning media using multimedia software. The initial product is then validated by material experts and media experts using a five-level Likert scale assessment instrument. The instrument's content validity is analyzed using Aiken's V, while the media's feasibility is analyzed descriptively based on the validator's score percentage. Expert input was used as the basis for revisions until a product was feasible for implementation. Expert validation and the Aiken's V index are common procedures in development research to ensure the quality of the instruments and products produced [21].

The fourth stage is implementation. The learning media that had been declared feasible were implemented in Pancasila Education lessons using a One-Group Pretest–Posttest design. Prior to the lesson, students were given a pretest to measure their initial level of environmental awareness. Next, students participated in learning using ecological citizenship-based digital media. After all activities were completed, a posttest was administered using the same instrument to determine the increase in students' environmental awareness. Additionally, teachers and students completed questionnaires responding to the practicality and ease of use of the media.

The fifth stage of evaluation was conducted formatively at each stage of development and summatively after the media's implementation. Formative evaluation was conducted based on the results of expert validation and limited trials, while summative evaluation aimed to determine the media's effectiveness in increasing students' environmental awareness based on pretest and posttest analysis.

Data collection techniques included observation, interviews, documentation, questionnaires, and tests. Observations and interviews were used to obtain data on learning needs, while questionnaires were used to obtain data on validity, practicality, and user responses to the media. Tests were used to measure students' increased environmental awareness before and after media use.

Data analysis was conducted quantitatively and descriptively. Expert validation data were analyzed using the Aiken's V index, while the media's suitability level was calculated using percentages. Media effectiveness data were analyzed using the Shapiro–Wilk normality test, followed by a paired sample t-test at a significance level of 0.05 using IBM SPSS Statistics software. Media is declared effective if there is a significant difference between pretest and posttest scores ($p < 0.05$). This analysis is widely used in learning media development research to evaluate product effectiveness on student learning outcomes [22], [23].

III. RESULTS AND DISCUSSION

The ecological citizenship-based digital learning media developed in this research underwent validation by three groups of validators: material experts, media experts, and language experts. The validation process aimed to ensure that the developed product met quality standards in terms of content, presentation, language, graphics, and the implementation of the ecological citizenship concept in Pancasila Education learning. Based on the results of the first validation phase, the validators provided several suggestions for improvement, including improving the integration of the material with learning outcomes, adding more contextual environmental case studies, simplifying the use of scientific terminology to suit student characteristics, refining the layout, ensuring consistent use of icons and colors, and adding reflection activities and environmental action projects as implementations of ecological citizenship values. All of this input was incorporated into the product revision process before the final validation phase.

The final validation results indicated that the digital learning media had improved in quality across all assessment aspects and received a Very Suitable category. The content appropriateness aspect received an average score of 4.81, or 96.2%, indicating that the material aligns with learning outcomes, is conceptually accurate, relevant to the context of Pancasila Education, and comprehensively integrates ecological citizenship values. In the presentation aspect, the media received an average score of 4.50, or 90.0%. These results indicate that the material presentation is structured coherently, interactively, and supported by the use of multimedia, which enhances student engagement in the learning process. The language aspect received an average score of 4.60, or 92.0%. This indicates that the language used meets the rules of good and correct Indonesian, is communicative, easily understood by students, and supports effective material delivery. The graphics aspect received the highest score, at 5.00, or 100%, indicating that the interface design, color selection, typography, illustrations, image quality, and media layout meet the standards for engaging, aesthetic, and user-friendly digital learning media.

Meanwhile, the implementation aspect of ecological citizenship-based digital learning media received an average score of 4.00, or 80.0%. Although it was already in the Very Feasible category, the validator still recommended that in future development, variations in local case studies, collaborative activities based on environmental projects, and more interactive feedback features be added to enhance the student learning experience. Overall, the average validation score for ecological citizenship-based digital learning media reached 4.58, or 91.6%, placing it in the Very Feasible category. These results indicate that the developed media met the feasibility standards in terms of material substance, learning design, language, visual presentation, and implementation of the ecological citizenship concept. Therefore, the media is suitable for use in the implementation phase to test its effectiveness in increasing students' environmental awareness.

1) Table 1. Results of Validation of the Feasibility of Ecological Citizenship-Based Digital Learning Media

No	Rated aspect	Average Score	Percentage (%)	Category
1	Content suitability	4,81	96,2	Very Worthy
2	Presentation	4,50	90,0	Very Worthy
3	Linguistics	4,60	92,0	Very Worthy
4	Graphics	5,00	100,0	Very Worthy
5	Implementation of digital learning media based on ecological citizenship	4,00	80,0	Very Worthy
Average Overall Aspects		4,58	91,6	Very Worthy

Based on Table 1, the graphic aspect obtained the highest score with a percentage of 100%, indicating that the media's

visual appearance was considered very attractive, consistent, and easy to use. The content feasibility aspect obtained a percentage of 96.2%, indicating that the material was in accordance with the learning objectives and successfully integrated the concept of ecological citizenship comprehensively. The language and presentation aspects obtained 92.0% and 90.0%, respectively, indicating that the media had a systematic presentation structure and used communicative language. Meanwhile, the media application aspect obtained 80.0%, which although it was the lowest score among all aspects, was still in the Very Feasible category and indicated that the media had been able to facilitate ecological citizenship-based learning effectively. Overall, the validation results indicated that the developed digital learning media had met the quality criteria for use in the learning process and was ready to proceed to the effectiveness trial stage on students.

Discussion

The research results show that the developed ecological citizenship-based digital learning media achieved an average validation score of 4.58, or 91.6%, and is therefore categorized as Very Feasible. This high level of feasibility indicates that the media meets the requirements of material substance, presentation, language, graphics, and implementation of the ecological citizenship concept. This finding indicates that the development process using the ADDIE model is capable of producing learning media that meet student needs and support Pancasila Education learning oriented towards strengthening environmental awareness.

The content feasibility aspect achieved the second-highest percentage at 96.2%, indicating that the material aligns with learning outcomes, is conceptually accurate, and integrates ecological citizenship values into Pancasila Education learning. This finding aligns with the results of a meta-analysis conducted by Rakhmawati et al. [24], which concluded that ecological citizenship-based learning materials have a strong influence on increasing students' environmental awareness, with a high effect size. This research confirms that integrating the concept of ecological citizenship into learning materials can foster ecological awareness, social responsibility, and pro-environmental behavior more effectively than conventional learning. The results of this study also showed that the graphics aspect achieved the highest score, at 100%. This indicates that the visual appearance, layout, illustrations, typography, and media navigation met the characteristics of engaging and user-friendly digital learning media. Good visual presentation contributes to increased learning motivation by creating a more interactive and enjoyable learning experience.

These findings are consistent with the results of a systematic review by Hajj-Hassan et al. [25], which showed that the use of digital technologies such as interactive multimedia, virtual reality, augmented reality, learning videos, and digital applications can increase student attention, strengthen understanding of environmental concepts, and foster sustainability awareness. In terms of presentation and language, the media achieved scores of 90.0% and 92.0%, respectively. These results indicate that the material was structured systematically, communicatively, easily

understood, and suited to the characteristics of the students. Interactive presentations through videos, infographics, quizzes, case studies, and environmental action projects provided opportunities for students to learn actively and connect the concepts learned to real-life environmental issues. This condition supports the constructivist theory, which states that knowledge is built through meaningful and contextual learning experiences.

Meanwhile, the implementation of ecological citizenship-based digital learning media received a score of 80.0%, which, although the lowest score compared to other aspects, still falls into the Very Adequate category. The validators provided several recommendations, including the addition of collaborative activities, a variety of local environmental case studies, and a reflection feature that encourages students to take concrete action. This input demonstrates that the development of digital learning media should not only focus on delivering information but also foster active student participation as responsible citizens of the environment.

The findings of this study reinforce the findings of Feriandi and Ulfah [26], who developed augmented reality-based Ecology Civics media. This study demonstrated that ecological citizenship-based digital media can improve ecological competence, learning interest, and student engagement in Pancasila Education. Similarities with this study lie in the use of digital technology as a means of internalizing ecological citizenship values. The difference is that the media developed in this study focuses not only on concept visualization but also integrates case studies, environmental action projects, interactive evaluations, and reflection as part of developing students' environmental awareness.

These findings are also supported by a study by Lestari, Afandi, and Ariyati [27], which states that education plays a central role in developing ecological citizenship through the integration of digital technology, contextual learning, and community participation. They emphasized that the use of digital platforms can improve ecological understanding while strengthening public awareness of the importance of maintaining environmental sustainability. Thus, digital learning media serves not only as a means of delivering material but also as a means of transforming students' values and behaviors toward becoming sustainable citizens.

The implications of this research indicate that the development of ecological citizenship-based digital learning media is an innovation relevant to the demands of 21st-century education and the implementation of Education for Sustainable Development (ESD). The developed media not only improves the quality of the learning process but also has the potential to shape ecological citizenship competencies, encompassing knowledge, attitudes, moral responsibility, decision-making skills, and active participation in resolving environmental issues. Therefore, this media can be an alternative learning method for Pancasila Education that supports the achievement of the Pancasila Student Profile, particularly the dimensions of faith and devotion to God Almighty, mutual cooperation, critical reasoning, and concern for environmental sustainability.

However, this research still has limitations. Validation was conducted on a limited number of validators and trial locations, so the generalizability of the research results still needs to be tested in more diverse school contexts. Future research is recommended to develop more immersive technology-based media, such as virtual reality, augmented reality, or artificial intelligence, and test their effectiveness using experimental designs with control groups to obtain stronger empirical evidence regarding the media's influence on increasing students' environmental awareness and ecological citizenship behavior.

IV. CONCLUSIONS

Based on the research results, it can be concluded that the ecological citizenship-based digital learning media developed using the ADDIE model meets the criteria for being highly suitable for use in Pancasila Education learning. Validation results by material experts, media experts, and language experts showed an average score of 4.58 or 91.6%, which falls into the Very Suitable category. The graphics aspect received the highest score of 100%, followed by content suitability (96.2%), language (92.0%), presentation (90.0%), and application of ecological citizenship-based learning media (80.0%). These results indicate that the developed media meets the appropriateness standards in terms of content, design, language, and learning implementation.

The development process, which began with needs analysis, design, development, implementation, and evaluation, successfully produced learning media that integrates ecological citizenship concepts into Pancasila Education materials through interactive multimedia presentations, environmental case studies, quizzes, environmental action projects, and reflection activities. These characteristics make media not only a means of delivering material but also a vehicle for fostering student awareness, responsibility, and participation in preserving the environment.

Research findings indicate that ecological citizenship-based digital learning media has the potential to improve the quality of learning while supporting the strengthening of students' environmental awareness. The integration of digital technology with ecological citizenship values provides a more contextual, interactive, and meaningful learning experience, encouraging students to connect learned concepts to real-life environmental issues.

This research contributes to the development of innovative Pancasila Education learning media that aligns with the principles of Education for Sustainable Development (ESD) and strengthens the Pancasila Student Profile. Therefore, ecological citizenship-based digital learning media can be used as an alternative learning method that supports the development of citizens with environmental literacy, ecological awareness, and a commitment to active participation in realizing sustainable development.

However, this research is limited to a single school trial with a relatively limited number of respondents. Further research is recommended to test the effectiveness of media on a wider sample, different levels of education, and develop more

innovative technology-based learning features, such as artificial intelligence, augmented reality, or virtual reality, so that the influence of media on increasing environmental awareness and ecological citizenship competencies can be studied more comprehensively.

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