International Journal of Education and Practice
2026 Vol. 14, No. 1, pp. 521-541
ISSN(e): 2310-3868
ISSN(p): 2311-6897
DOI: 10.18488/61.v14i1.4766

SAC interactive e-modules: A step toward green economy for elementary students

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Article History
Received: 30 June 2025
Revised: 27 November 2025
Accepted: 22 January 2026
Published: 11 February 2026

Keywords
Elementary school
E-modules
Environmental education
Green economy
Smart apps creator.

ABSTRACT

In order to help primary school pupils better grasp the concept of a green economy, this study aims to design an interactive e-module utilizing Smart Apps Creator (SAC). The study employed the Analysis, Design, Development, Implementation, Evaluation (ADDIE) model to develop the e-module, which was tested in two stages: a limited trial involving 48 schools and a field trial involving 133 schools. The process began with problem identification and needs analysis, followed by a literature review to strengthen the theoretical framework and identify findings from similar studies. Subsequently, product specifications were defined, appropriate media were selected, and instruments for validation and product effectiveness testing were developed. After finalizing the product design, it was validated by two media experts and two content experts. Respondents provided positive feedback, and validation results from media and content specialists demonstrated the e-module's viability. Statistical analysis revealed a significant improvement in students' pre- and post-test scores, confirming that the e-module effectively enhanced their understanding of the green economy. The analysis showed that the Sig. (2-tailed) value was 0.000, which is less than 0.05, indicating a statistically significant difference between pre-test and post-test scores. This significant difference was observed in both the limited trial and the field trial phases. The findings suggest that SAC-based e-modules can serve as engaging and accessible learning tools to support environmental education and promote sustainable practices.

Contribution/Originality: This study contributes to the development of SAC-based interactive e-modules for green economy education in primary schools. The originality of this study lies in integrating the ADDIE model with expert validation and large-scale trials, which empirically confirmed significant learning gains in environmental and sustainability awareness.

1. INTRODUCTION

According to Nižetić, Djilali, Papadopoulos, and Rodrigues (2019) the growing problem of the global green economy is a consequence of the increasing use of conventional energy sources to fuel economic expansion, which in turn causes environmental deterioration (Shao, Zhong, Liu, & Li, 2021) and the climate change that is occurring, generally considered a serious threat to the sustainable development of human society (Du & Li, 2019). A multifarious waste environment due to people's consumption patterns (Karjoko, Handayani, Jaelani, & Hayat, 2022), the surplus of waste is then openly and uncontrollably burned or dumped into waterways (Fatimah, Govindan, Murniningsih, &

Setiawan, 2020), causing water and air pollution. Indonesia's Environmental Quality Index (EQI) in 2023 shows that the water quality index is 54.59 (medium quality) and the air quality index is 88.67 (good quality). Natural degradation is an issue that dominates environmental issues in various ecoregions in Indonesia.

There are three factors that cause natural damage: human activities, technological choices, and structural institutions. One of the factors of human activities that damage the natural environment is the lack of awareness, understanding, and concern of the community. As a result, environmental education in the home and the classroom must be a priority. To act properly toward the environment and to have the intention to do so, environmental education is crucial (Zhang, Huang, Yin, & Gong, 2015). Environmental education plays a key role in shaping the development of attitudes, values, knowledge, dispositions, and skills necessary to practice pro-environmental behaviors (Ardoin & Bowers, 2020) in two ways: changing individual attitudes toward the environment and improving community attitudes toward environmental concern and awareness (Liao & Li, 2019).

Integrating environmental concepts into the curriculum, core-oriented and applied to elementary school subjects (Torkar, 2014), is a crucial step in preparing future generations who care about the environment. Incorporating environmental or green education into the school curriculum has as its overarching goal the development of environmentally conscious citizens who can begin to take action at a young age (Alwasi, Fadhilah, Nurohmah, & Rustini, 2023) to be able to apply environmental care attitudes in everyday life (Rezkita & Wardani, 2018) and to be agents of change for sustainability (Iliopoulou, 2018).

The efficacy of learning in this digital age can be greatly enhanced by combining information and communication technology (ICT) with interesting and interactive teaching methods (Monroe, Plate, Oxarart, Bowers, & Chaves, 2019). Media such as Kahoot (Pereira, Dinis, & Gouveia, 2020), SARTHA-Apps (Uda, Prasetyo, Dopo, Uda, & Basrowi, 2024), game performance (Lin, Hsieh, Hou, & Wang, 2019) and Immersive Game (Lau, 2023) have been employed in environmental education. The media is currently subpar because the application needs a lot of storage memory (Uda et al., 2024). Additionally, the different game components need more help and direction in order to develop focus strategies (Lin et al., 2019) for discovery learning (Lau, 2023), rather than as a preventive measure and implemented at the student level (Pereira et al., 2020), rather than in elementary school. However, these media have several major limitations in the context of environmental education for elementary school students: they are not all specifically designed to foster early environmental awareness, require access to high-capacity devices, and are often not integrated with the prevailing environmental curriculum at the elementary school level. These shortcomings indicate a gap in the provision of effective, affordable, and age-appropriate environmental learning media for elementary school students.

Finding a different solution is therefore required; this involves creating an interactive Smart Apps Creator (SAC) e-module, as these learning resources are seen to be crucial for promoting a green economy in elementary school pupils. The use of Smart Apps Creator (SAC) as a platform for interactive digital content is essential. The selection of SAC was based on its affordability and user-friendliness (Suhartati, 2021) its ability to incorporate text, photos, music, graphics, videos, animations, and navigation buttons without requiring expertise in coding (Ramanda, Yogica, Rustiono, & Selaras, 2023) its ability to produce applications in HTML and EXE formats that are compatible with a variety of devices, including computers, laptops, tablets, and smartphones (Rachmat, Syahwin, & Ramadani, 2022), and it might be an Android application prototype that gets added to the Play Store (Suryaningtyas, Nugroho, Cahyono, Nababan, & Santosa, 2019).

Regarding environmental education, it has been carried out in various countries. In Spain, sustainability education has been implemented (Robina-Ramírez, Medina Merodio, & McCallum, 2020), ethics, environmental culture, and scientific knowledge in Russia (Shutaleva, Nikonova, Savchenko, & Martyushev, 2020), environmental literacy in Colombia (Edsand & Broich, 2020), a green school partnership project in Taiwan (Olsson, Gericke, Boeve-de Pauw, Berglund, & Chang, 2019) and the Climate Change + Me project in Australia (Cutter-Mackenzie & Rousell, 2019). Seeing this, environmental education techniques are different according to regional and country conditions. In

Indonesia, a comprehensive solution or way of environmental education is needed, namely, with media that can be widely accessed cheaply and easily. One of them is with the interactive media SAC. Using the environmental curriculum as a foundation, this research takes a fresh approach by creating an interactive e-module of SAC to educate primary school pupils about the importance of a green economy.

Unlike previous research that tends to focus on environmental learning media at the secondary or tertiary levels, this study offers a new approach by developing an interactive e-module based on Smart Apps Creator (SAC) specifically designed for elementary school students and directly integrated with the environmental curriculum. The uniqueness of this approach lies in the use of lightweight digital technology that can be used offline, is easily accessible, and does not require programming skills, making it highly relevant for elementary education contexts in areas with limited digital infrastructure. The study's main contribution lies in the development of learning media that combine environmental sustainability principles with inclusive and applicable educational technology for early childhood students. In addition to providing a practical solution to the need for learning media that is appropriate to the capacity of students and teachers at the elementary school level, this study also enriches the literature on the integration of environmental education based on local technology. Methodologically, the use of the ADDIE development model, complemented by expert validation and large-scale field testing, also strengthens the empirical findings on the effectiveness of the e-module in improving understanding of green economy concepts. Therefore, this study not only offers innovation in the form of a product but also a development approach that can be replicated and adapted in other educational contexts.

2. LITERATURE REVIEW

2.1. Green Economy in the Context of Education

The 21st United Nations Meeting on Climate Change took place in Paris, France, from November 30 to December 11, 2015. The conference's primary goal was to establish a new, internationally enforceable, and legally binding accord to decrease emissions. At the 21st Paris Climate Change Conference (COP21), all participating nations pledged to work together to build a green economy that uses less carbon (Shuai & Fan, 2020). Thus, in order to guarantee sustainable development, nations all over the globe have made the creation of a green economy a strategic objective.

Due to the enormous changes in biological structure and climate that come with climate change, the environment will only worsen over time; hence, it is vital that people all over the world pay attention to environmental issues (Abid, Ikram, Wu, & Ferasso, 2021). The environmental issues in question include microplastic (MP) pollutants found in soil, air, and aquatic environments (Sol, Laca, Laca, & Díaz, 2020) electronic waste (e-waste) (Abalansa, El Mahrad, Icely, & Newton, 2021) the widespread use of pesticide residues in the environment to exceed concentrations (Tang, Lenzen, McBratney, & Maggi, 2021) Pharmaceutical pollution of the world's rivers (Wilkinson et al., 2022) metal pollution (Briffa, Sinagra, & Blundell, 2020) vehicle emissions (Wang, Chen, Zhu, Wang, & Zhang, 2020).

Environmental and social dangers pose a threat to society, endangering human existence in the long run (Durán-Romero et al., 2020). The extinction of natural resources, rising emission levels, and the continuous increase in human population will worsen by 2050 if pragmatic measures are not taken to remedy the situation (Ali, Anufriev, & Amfo, 2021).

Education plays a key role in preserving the environment, as it can embed awareness and understanding of the importance of protecting nature from an early age. It is during childhood that the motivation to be environmentally friendly is formed and may have lifelong effects (Evans et al., 2007). Improving people's environmental consciousness through increased environmental literacy is the primary goal of environmental education initiatives (Pooley & O'Connor, 2000). Therefore, providing knowledge and creating experiences to change beliefs, attitudes, and most importantly, behaviour (Frantz & Mayer, 2014).

2.2. Technology in Education

All throughout the educational system, digital technologies have brought about a paradigm change in the pursuit of high-quality education (Haleem, Javaid, Qadri, & Suman, 2022). According to Ilyas et al. (2023), technology has revolutionized education by making it more accessible, efficient, and effective (Ilyas et al., 2023). Media based on technology for learning is now both required and expected in today's world (Muhson, 2010). The two main goals of incorporating technology into the classroom are (i) improving instruction through the strategic use of digital tools and (ii) helping both students and educators become more proficient in the use of technology in the classroom (Costa, Castano-Munoz, & Kampylis, 2021). Educators are deeply concerned about the integration of digital technologies into the school ecosystem, as it is a complex and ongoing process that affects many different players (Timotheou et al., 2023). One of the outcomes of this integration is the increased behavioral, emotional, and cognitive engagement of students (Bond, Buntins, Bedenlier, Zawacki-Richter, & Kerres, 2020). Teachers and students alike have a great opportunity to enhance classroom instruction by utilizing technology (Lawrence & Tar, 2018).

To guarantee effective delivery, effective utilization, and a favorable impact on learners, it appears that technology integration in education is a crucial learning medium (Al-Fraihat, Joy, Masa'deh, & Sinclair, 2020). The use of technology provides greater flexibility in teaching, which allows, for example, taking into consideration different types of intelligences and interests (Hol & Aydin, 2020). Teaching and learning are both improved by digital technology (Fernández-Gutiérrez, Gimenez, & Calero, 2020); therefore, it is increasingly used for learning and educational purposes (Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020). Increasing student access to information and a wider range of learning resources (Spiezia, 2010), enhancing individualized instruction and better monitoring of student progress are all ways in which technology plays an essential role in the classroom (Bingimlas, 2009; Falck, Mang, & Woessmann, 2018). Lessons can be more comprehensive, engaging, or interactive, and they can also enhance teaching materials (Comi, Argentin, Gui, Origo, & Pagani, 2017). Using technology in the classroom can also help students hone skills like critical thinking, process comprehension, and problem solving, all of which are essential for success in the workplace (Haleem et al., 2022). Technology becomes a medium to facilitate students individually in accessing collaborative and cooperative learning (Pinto & Leite, 2020). Therefore, any learning technology that captures students' interest can improve their learning (Turan & Atila, 2021).

In the context of education, this reality presents both opportunities and challenges for instructors as they apply the learning process in schools. The responsibility for teaching students how to effectively use technology lies with educators (Basilotta-Gómez-Pablos, Matarranz, Casado-Aranda, & Otto, 2022) and integrating it into the learning process (Summak, Bağlıbel, & Samancıoğlu, 2010). Whether or not educators are able to be inspired or constrained by technological advancements will determine the efficacy of this technology utilization (John & Sutherland, 2005; Szymkowiak, Melović, Dabić, Jeganathan, & Kundi, 2021). Because with the usage of technology, teachers can use it to prepare teaching materials, making lessons more complete, engaging, and personalized thanks to wider opportunities to discover textual and audiovisual content (Comi et al., 2017) for the purpose of facilitating pupils' ability to utilize both their visual and aural senses to arrange information (Hillmayr, Ziernwald, Reinhold, Hofer, & Reiss, 2020). In contrast, both the quality of instruction and instructors' reputations depend on how well they use technology in the classroom (Fekete, 2021).

2.3. Smart Apps Creator (SAC)

The use of learning media is rapidly expanding as a means to inspire and engage students in the educational process. There are many variations in the types of technological interventions used in learning (Archer et al., 2014) such as laptops and cell phones (Sung, Chang, & Liu, 2016) Virtual Reality (VR) (Gülbahar, 2007) Augmented Reality (AR) (Geng & Yamada, 2021) Artificial Intelligence (Gao, Li, & Liu, 2021) Perangkat Digital (Hillmayr et al., 2020) and digital modules, which, among other things, are strong predictors of successful and efficient learning (Alnedral, Ihsan, Mario, Aldani, & Sari, 2023). Teachers have easy access to a wealth of technology that can improve classroom

instruction (Antonietti, Cattaneo, & Amenduni, 2022), but it has not been specifically designed for learning (Mishra & Koehler, 2006) and effectively integrated into the curriculum to enhance student creativity (Tang, Mao, Naumann, & Xing, 2022). It is imperative that more affordable technology be created (Alimović, 2024) based on learning needs (Bower & Sturman, 2015) and depending on the purpose of the activity (Gülbahar, 2007).

This study used SAC as its digital tool. With SAC, you can create mobile apps for iOS and Android without writing a single line of code. The apps you develop can be exported in HTML5 and .exe formats. SAC is an interactive digital medium that enables the creation of mobile-friendly audiovisual content, which can be uploaded to the Play Store (Widiyatmoko, Utaminingsih, & Santoso, 2021). The free and easy-to-use nature of the smart apps creation software is a major factor in its appeal. As an added bonus, creating an APK (application that can be applied on Android) using smart applications maker on a laptop or PC is highly compatible. Since most students own Android devices, they should have no trouble installing the APK file that their teacher has provided, making it convenient for them to use in their learning, regardless of their location. Smart Apps Developer doesn't need a pricey quota because it can be used offline. First, Smart Apps Creators make it easy and inexpensive for developers to produce apps. Second, users don't need an internet connection to use the app; third, it's portable; and fourth, it works on any device. Everyone can get in on the action because there's no cost and no time restriction on the download (Suhartati, 2021). Research also demonstrates that students' engagement, motivation, creativity, and learning outcomes can all be improved when Smart Apps Creator (SAC) is used in the classroom (Suhartati, 2021). In reality, teachers can use technology in the digital age by developing mobile apps with Smart Apps Creator (SAC) (Karim, Savitri, & Hasbullah, 2020)

3. METHODOLOGY

3.1. Research Model

Research and development using the ADDIE development paradigm (Analysis - Design - Development - Implementation - Evaluation) is a type of research used in this activity. We conduct research to learn about user needs, and then we design and test Smart Apps Creator (SAC) Interactive E-Module products to assess their effectiveness and readiness. The process began with a problem and needs analysis, followed by a literature review to strengthen the theoretical framework and identify similar research findings. The next step included defining product specifications, selecting appropriate media, and developing instruments for validation and product effectiveness testing. Once the product design was completed, it was validated by two media experts and two content experts. Product trials were carried out in two stages. The first stage was a limited trial conducted in elementary schools in Kartasura District, Central Java, involving a population and a sample of 48 schools. This was followed by a broader field trial in Sukoharjo Regency, Central Java, with a population of 399 schools and a sample of 133 schools. The evaluation focused on measuring the extent to which the product development objectives were achieved to ensure the product's applicability and usability in real-world settings.

3.2. Participant/Sample

Product trials were conducted in two stages, namely limited trials in elementary schools in Kartasura District, Central Java, with a population of 48 schools and a sample of 48 schools. The selection of all these schools was based on their small population size, allowing for the use of total sampling techniques (Sugiyono, 2013). Furthermore, these locations were chosen because they have relatively homogeneous characteristics and are easily accessible, making it easier for researchers to coordinate and monitor. This limited trial aimed to obtain initial input regarding the technical feasibility and substance of the product before its wider implementation. It was followed by a broader field trial in Sukoharjo Regency, Central Java, with a population of 399 schools and a sample of 133 schools. According to Arikunto (2010), if the number of subjects is more than 100, then taking a sample of 25%–30% or more of the total population is sufficiently representative, depending on the homogeneity of the population and the research objectives. The evaluation of the results focused on the achievement of product development objectives and testing the Technology

Readiness Level (TRL) to ensure the usability of the product in the real world. Figure 1. Illustrates the ADDIE framework applied in this study.

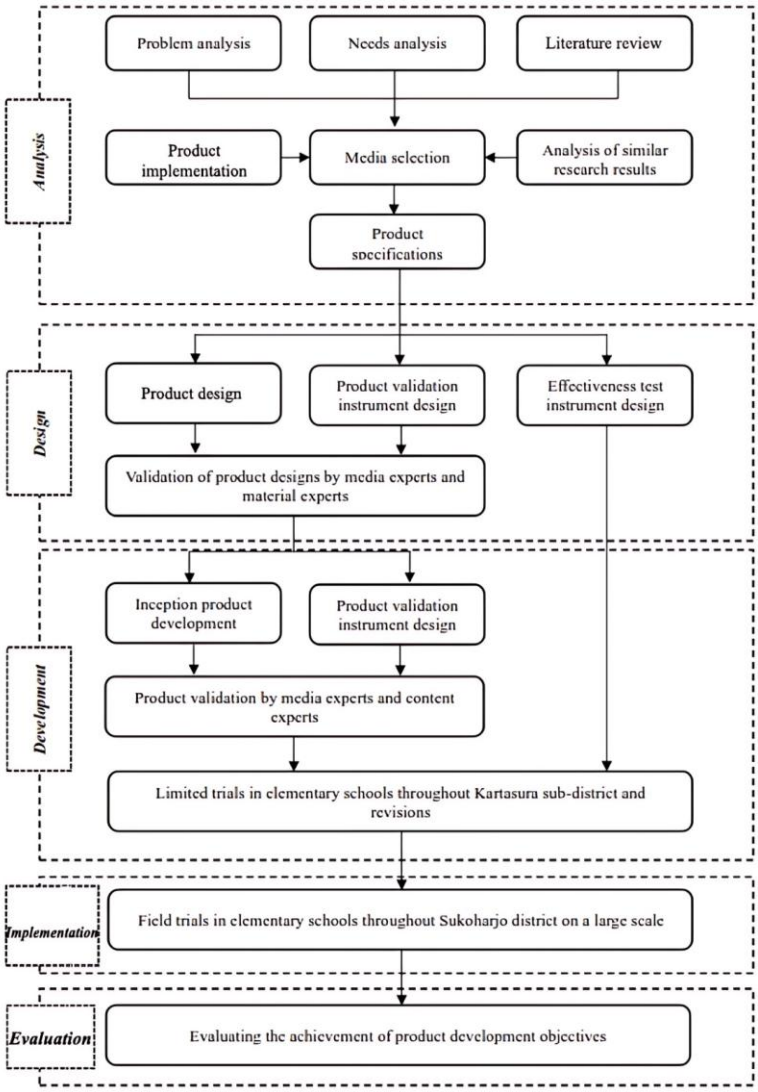

Figure 1. ADDIE framework.

3.3. Data Collection Method

Data analysis used in research on the development of smart apps creator (SAC) interactive e-modules, as an effort to understand the green economy in elementary school students, is as follows:

a. The needs analysis questionnaire and the carrying capacity of the product application

This questionnaire is used to find out the learning process and media utilization used by teachers, with aspects according to the instrument framework in Table 1.

Table 1. Instrument framework for analysing the needs and carrying capacity of a product application.

Aspect	Dimension
Learning conditions	View of learning
	The use of methods in learning
	Difficulties faced during learning
The use of learning media	Learning media that is used
	Display of the desired learning media
	Specifications of hp/Laptop

A needs analysis questionnaire was distributed to elementary school teachers to identify learning conditions, media used, obstacles encountered, and the readiness of students' devices. This instrument was designed based on several aspects, such as perspectives on learning, methods used, difficulties in the teaching and learning process, and expectations for ideal learning media.

b. Expert validation questionnaire

Media expert validation questionnaires are used to obtain data on the feasibility of media and materials. This validation involved two media experts and two subject matter experts with backgrounds and expertise relevant to the e-module development objectives. The two media experts are lecturers and practitioners in the fields of learning technology and digital educational content development, thus possessing the competence to assess the quality of visual displays, navigation structures, and media integration within digital-based learning processes. The two subject matter experts come from educational backgrounds and from national research institutions (BRIN) that focus on environmental sustainability. The two subject matter experts assessed the e-module content in terms of its suitability to the curriculum, the accuracy of the environmental education content, the use of accessible language, the completeness of the evaluation components, and the integration of the material with the green economy. The questionnaire uses a Likert scale with four options, with aspects according to the media expert validation instrument grid in Table 2 and material experts in Table 3.

Table 2. Media expert validation instrument grid.

Aspect	Dimension
Organization	Readability of text on the E-module
	Completeness of the E-module section
Attractiveness	Appearance of E-module content
	Appearance of evaluation questions
	Provision of images, illustrations, and animations
Letters and Images	Letter colours and letter shapes are appropriate
	Appropriate picture

Table 3. Material expert validation instrument grid.

Aspect	Dimension
Self instruction	Clarity of learning objectives
	Learning material packaging
	Material supported with examples and illustrations
	Availability of evaluation questions
	Tasks and questions are presented relevant to the material
	Use of simple and communicative language
	Availability of material summary
	Availability of the assessment matrix
	Availability of feedback on the assessment
Self contained	Contains all learning materials for one competency standard or basic competency as a whole.
Adaptive	E-modules adapt to technological developments.
User Friendly	Instructions are easy to implement
	Information is easy to use

Analysis of the validators' assessment calculations by determining the value and assessment criteria.

Table 4 Validation assessment criteria used by media and content experts to evaluate the feasibility of the SAC-based interactive e-module.

Table 4. Validation assessment criteria.

Description	Score
Very good	4
Good	3
Poor	2
Very poor	1

Next is to determine the percentage of validator assessment using the following formula:

$$\% = \frac{\sum \text{number of validator answers}}{\sum \text{highest score validator}} \text{ x } 100\%$$

For the percentage criteria for validation of the feasibility of learning media obtained:

Table 5 Percentage-based validator assessment criteria used to determine the feasibility of the SAC-based e-module.

Table 5. Validation criteria.

Validator assessment percentage	Description
0% – 20%	Very invalid/Feasible
21% – 40%	Invalid / Feasible
41% – 60 %	Quite Valid/Feasible
61% – 80%	Valid/Feasible
81% – 100%	Very Valid/Feasible

Based on the percentage of validation criteria, it can be said to be valid if the average percentage results obtained reach a percentage ≥ 61% with the criteria "valid/feasible" and the average percentage results obtained reach a percentage ≥ 81% with the criteria "very valid/feasible".

c. Product effectiveness test (test)

The effectiveness test design used in this study is a one-group pretest-posttest design.

O_1..... X .....O_2

Description:

O1: Pretest in the experimental class.

X: Treatment.

O2: Posttest in the experimental class.

Examining the statistical significance of the pre- and post-test results in the SPSS program allows one to ascertain the efficacy. Product efficacy evaluation (non-experimental). Finding out how the instructor feels about using the SAC Interactive E-Module is the whole point of this assessment. The questionnaire uses a Likert scale with four choices, with aspects according to the media expert validation instrument framework in Table 6.

Table 6. Grid for users.

Aspect	Dimension
Material	Relevance of E-module material
	Questions that are provided
	Language in the delivery of material
Media	Readability of text or writing in the appearance of the E-Module
	Images, illustrations, and animations
	Colour composition
Module learning	Interest in the module
	Learning activities

4. RESULTS

4.1. Teacher Needs

At this stage, an analysis of the needs and carrying capacity of product application is carried out to determine the learning process and media utilization used by 181 teachers in sample schools. The results of the questionnaire filled out, tested for validity and reliability, are as in Table 7 and Table 8.

Table 7. Validity test of the teacher needs questionnaire.

Aspect	Dimension	Indicator	r	Information
Learning conditions	Views on learning	X1	0.646**	Valid
		X2	0.646**	Valid
		X3	0.511**	Valid
	The use of methods in learning	X4	0.646**	Valid
		X5	0.511**	Valid
		X6	0.646**	Valid
	Difficulties that are faced during learning	X7	0.511**	Valid
		X8	0.518**	Valid
		X9	0.432**	Valid
The use of learning media	Learning media that is used	X10	0.518**	Valid
		X11	0.632**	Valid
		X12	0.518**	Valid
	Desired learning media display	X13	0.518**	Valid
		X14	0.432**	Valid
		X15	0.652**	Valid
	Specification of hp/laptop	X16	0.646**	Valid
		X17	0.432**	Valid
		X18	0.652**	Valid

Note: ** indicates that r-count > r-table (0.1451) at N = 181 and $\alpha = 0.05$, therefore all items are valid.

Table 8. Reliability test of the teacher needs questionnaire.

Cronbach's alpha	Information
0.870	Reliable

4.2. Assessment of Material Experts and Media Experts

Once the content is generated, the following step is to validate the materials and media with the help of two experts in the field. This will ensure that the materials and media are valid and feasible before they are used in limited trials and field trials. Table 9 displays the results of the evaluations conducted by material experts compared to those conducted by media experts.

Table 9. Assessment of material experts.

Aspect	Limited trial		Field trial	
	Material experts	Media experts	Material experts	Media experts
Percentage	77.88%	76.78%	85.71%	84.61%
Criteria	Valid/Feasible	Valid/Feasible	Very Valid/Feasible	Very Valid/Feasible
Suggestions	The material presented is added, and a place for students to interact is added	The features used are added to make it more interesting, and use more interesting words	Add a variety of assessments	The features used are added to make it more interesting.
Improvements	Adding material, adding a discussion page	Adding a link feature to YouTube, changing formal sentences to sentences that are easy for students to understand	Adding practice questions with different test techniques	Adding several features of practice questions with different test techniques

4.3. Effectiveness of the E-Module in Improving Students' Understanding of the Green Economy

This research aims to determine the effectiveness of the Smart Apps Creator (SAC) interactive e-module product with the hypothesis:

a. Alternative hypothesis (Ha): there is a significant difference between the pre-test and post test scores.

b. Null hypothesis (H0): there is no significant difference between the pre-test and post test scores.

A summary of the research results can be seen in:

Table 10. Research hypothesis testing results.

Test	Value	Normalities		Homogeneity		Paired Samples t Test	
		Sig.	Information	Sig.	Information	Sig. (2-tailed)	Information
Limited	Pre-test	0.396	Normal distribution	0.430	Homogeneous data	0.000	H0; rejected Ha; accepted
	Post-test	0.128	Normal distribution				
Field	Pre-test	0.000	Non-Normal Distribution	0.079	Homogeneous data	0.000	H0; rejected Ha; accepted
	Post-test	0.000	Non-normal distribution				

As shown in Figure 2, this is the stage when the teacher's response is also reviewed. Three aspects are taken into consideration: material feasibility, media feasibility, and interest in the interactive e-module SAC.

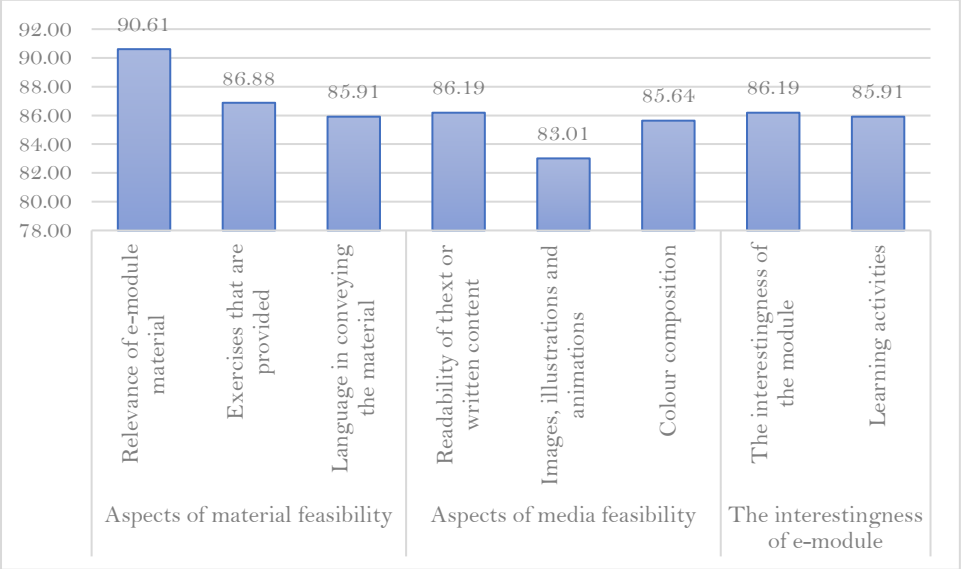

Figure 2. Percentage of teacher responses to the Smart Apps Creator (SAC) interactive E-module.

5. DISCUSSION

5.1. Teacher Needs

The validity test results in Table 7 show that all indicators have an r value of more than 0.1451, so all indicators have fulfilled the data validity requirements. The basis for making reliability test decisions can be seen from the 18 question items, where Cronbach's Alpha is 0.870, which is greater than 0.60, indicating reliability. The following conclusions can be drawn from the examination of how technology-based learning is viewed by teachers:

1. The majority of teachers believe that technology-based learning is highly advantageous for students. It influences learning more broadly and offers learners a flexible method of instruction (Cidral, Oliveira, Di Felice, & Aparicio, 2018). Additionally, they are at ease using technology in the classroom and believe that e-modules can enhance student learning. Recent advancements in digital modules include their ease of use, the ability to display visual content (such as images or videos), and their seamless integration with mobile devices (such as smartphones and laptops) for learning (Bachri, Hakiki, Wibowo, Amini, & Nursaribilah, 2024; Nopriana,

Herman, & Martadiputra, 2023). Digital modules are also an effective way to improve students' conceptual understanding and critical thinking skills (Hasanati, Supriana, & Mufti, 2023).

2. Many teachers have implemented interactive learning in the classroom and combined various learning methods. However, there are some who still use the traditional lecture method as the main approach, especially in certain situations. The traditional lecture method is teacher-centered learning, where learners complete the learning without developing critical reasoning skills (Alrahlah, 2016). The classroom atmosphere becomes inactive, and most students receive knowledge passively (Li et al., 2022).
3. Some teachers report difficulty in integrating technology into the classroom and feel that students struggle to understand material without visual supports. As visual learners, students remember more (Rogowsky, Calhoun, & Tallal, 2020) due to the widespread reliance on technology (Shorey, Chan, Rajendran, & Ang, 2021).

5.2. Assessment of Material Experts and Media Experts

The media and learning resources were determined to be appropriate for use in the classroom based on the evaluations made by specialists in the field and in the restricted trial. The addition of interactive features, a variety of assessments, and integration with external technology contribute positively to student engagement and understanding. The use of language that is appropriate to the students' level is also an important key in facilitating effective learning. The development of this learning application introduces new approaches to learning. The app is user-friendly, makes the content more engaging, and will help students learn more efficiently. When it comes to physically transferring information and facts, digital media for learning is more effective and relevant (Mourlam, Strouse, Newland, & Lin, 2019).

5.3. Effectiveness of the E-Module in Improving Students' Understanding of the Green Economy

Effectiveness measures success in an educational situation of interaction between students and teachers to achieve learning objectives. Effectiveness is a measure of how well work is done, meaning that work done according to schedule can be considered efficient in terms of time, cost, and quality (Zidane & Olsson, 2017). Performance can generally indicate how far learning objectives have been achieved. Learning must pay attention to the effectiveness of learning to achieve the desired goals of students. Learning effectiveness is not only reflected in student performance (Zidane & Olsson, 2017) but also in supporting opportunities, student interest in the learning process, and learning methods that support the success or failure of learning objectives (Ames & Archer, 1988; Biggs, 1999; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013).

The development of science and technology has greatly influenced various fields, including education. Smart Apps Creator (SAC) interactive e-modules are products of multimedia technology. The utilization of E-Modules in learning activities is a form of technology application. In its implementation, teaching and learning activities using E-Modules are very effective in enhancing students' abilities (Delita, Berutu, & Nofrion, 2022) compared to only emphasizing conventional learning. At the elementary school level, children at that age prefer to play rather than learn. By using E-Modul media in learning for students it will minimize the level of boredom during learning activities (Munir, Fitrianti, & Megasari, 2022). Students will better understand the material explained by the teacher (Schneider & Krajcik, 2002; Wood, 2000), which means that by applying E-Modules in learning, it can provide increased learning outcomes and enthusiasm, especially for implementative subjects.

Students have a greater familiarity with mobile phones than their parents do. Students' abilities will be prepared for the digital age through the integration of mobile technology into the classroom (Sun, Yao, You, Du, & Luo, 2018). Smart Apps Creator (SAC), as a platform for interactive digital content, was based on its affordability and user-friendliness (Suhartati, 2021) its ability to incorporate text, photos, music, graphics, videos, animations, and navigation buttons without requiring expertise in coding (Ramanda et al., 2023) its ability to produce applications in HTML and EXE formats that are compatible with a variety of devices, including computers, laptops, tablets, and

smartphones (Rachmat et al., 2022) and it might be an Android application prototype that gets added to the Play Store (Suryaningtyas et al., 2019).

In a limited trial, the data were tested for normality using the Kolmogorov-Smirnov method with a Monte Carlo approach. The results showed that the significance value (Sig.) for the pre-test was 0.396, and the post-test was 0.128. Both values were >0.05, indicating that the data at this stage were normally distributed. Meanwhile, in the field trial, the normality test results showed that the Sig. value for the pre-test was 0.000 and for the post-test was 0.000. Both values were <0.05, indicating that the data were not normally distributed.

A paired t-test was used in both the limited and field tests despite the normality violation, especially when the sample size was large, as supported by several research studies. The t-test is known as "robust" to violations of the normality assumption, applied as long as other conditions are met; for example, there are no outliers that are too extreme, and the sample size is large enough to balance the normality violation (Deria, Hoyyi, & Mustafid, 2019). Next, a homogeneity of variance test was conducted to ensure the similarity of data distribution. In the limited test, the Sig. value was 0.430, and in the field test, it was 0.079. Since both values were > 0.05, this indicates that the understanding of the green economy among elementary school students on the pre-test and post-test scores, in both the limited trial and field trial, has homogeneous variance. The effectiveness test results using a paired samples t-test showed that there was a significant difference between the pre-test and post-test scores. In the limited test, the Sig. (2-tailed) value was 0.000 < 0.05, so H_0 was rejected and H_a was accepted, indicating a significant increase in student understanding after using the e-module. A similar result was observed in the field test, where the Sig. (2-tailed) value remained at 0.000, confirming a significant difference between the pre-test and post-test scores in both tests. These findings suggest that the use of the Smart Apps Creator (SAC) interactive e-modules effectively enhances elementary school students' understanding of a green economy. This improvement is attributed to the engaging features of the SAC e-module, which offers animations and videos that facilitate learning. The utilization of animated videos not only positively impacts the learning process and increases students' interest but also significantly improves learning outcomes. Based on data obtained from several journals, learning with videos can help students improve their academic performance (Liu, 2016; Mudasih & Subroto, 2019; Nurwulan, Nugraha, & Hendrawan, 2020; Orús et al., 2016; Tani, Manuguerra, & Khan, 2022). In addition to enhancing learning results, using animated videos as a teaching tool has the potential to affect student behavior (Barut & Dursun, 2022; Bravo, Amante, Simo, Enache, & Fernandez, 2011) by inspiring and fostering achievement and elevating students' spirits, the use of animated videos is also one of the most effective methods for the learning process, both in groups and individually. Why is that? Because learning through audio-visual videos can create an environment that is engaging and conducive to understanding (Preis, Kociński, Hafke-Dys, & Wrzosek, 2015), enjoyable (Marlena, Dwijayanti, & Widayati, 2019), and neither monotonous nor boring (Tugrul, 2012), in order to encourage good learning results (Hilmi, 2017) and stimulate students' enthusiasm in studying (Yeh, 2022). With entertaining content, the interactive e-module smart applications creator (SAC) can develop students' critical thinking abilities. In addition, the easy-to-use smart apps creator (SAC) interactive e-modules allow students to learn independently. Therefore, a learning app based on Android can be created using the Smart Apps Creator (SAC) interactive e-module to help primary school kids hone their critical thinking abilities.

Figure 2 shows the three dimensions that are considered at this level of evaluating the teacher's response: material feasibility, media feasibility, and interest in the interactive e-module smart applications creator (SAC). A score of 90.61% was achieved in the analysis of the E-module material's relevance. This indicates that teachers feel the material presented in the module is highly relevant to learning, both in terms of the material itself and the expected learning objectives. This aligns with the instructional alignment concept, which states that to achieve the best possible learning outcomes, learning materials must be consistent with learning objectives and assessment activities (Martone & Sireci, 2009; Polikoff & Porter, 2014). Supporting meaningful and contextualized learning also heavily relies on materials that are suitable for the learning environment (Hill & Hannafin, 2001). Positive responses were also observed

regarding the questions provided, with a score of 86.88%. Teachers felt that the questions prepared were suitable for the material and could help students in understanding and applying the concepts that had been learned. This reinforces the importance of integrating formative assessment in digital learning media. Appropriately designed assessments can encourage students to reflect on their understanding (Sadler, 1989) as well as provide feedback to teachers in adjusting teaching strategies (Van Der Steen, van Schilt-Mol, van der Vleuten, & Joosten-ten Brinke, 2023). In the digital context, contextualized and interactive question design can also enhance students' active engagement in the learning process (Malaluan & Andrade, 2023). In terms of linguistic proficiency, a score of 85.91% was achieved. This demonstrates how the module's language is designed to be easily understood by students, which helps in efficiently delivering the subject.

A whopping 86.19% of teachers gave the module's text or writing high marks for legibility and ease of understanding. This score indicates that the layout and use of fonts in the E-Module support readability. This demonstrates the application of the principle of cognitive load theory, which emphasizes the importance of arranging information simply so as not to burden students' working memory (Cook, 2006; Meguerdichian, Walker, & Bajaj, 2016; Niaz & Logie, 1993). Communicative language and the use of appropriate sentence structure also accelerate the process of concept internalization (Bazerman, 2012), especially for students with diverse reading abilities, the aspect of pictures, illustrations, and animations was rated quite well, with a score of 83.01%. This indicates that teachers felt the use of visuals in the module could be more optimal. The colour composition aspect was also rated similarly to the images and illustrations, at 85.64%. This may suggest that although the colour composition of the module is not poor, there is room for improvement to make it more visually appealing. In multimedia learning theory, effective visuals should not only enhance the display aesthetically but also serve clear instructional functions: reinforcing understanding (Eilam & Gilbert, 2014), explaining processes (Bobek & Tversky, 2016) and reducing cognitive load (Mayer & Moreno, 2003). Therefore, revisions to the quality of illustrations and color harmonization should be considered to enhance the appeal and effectiveness of visual communication (Davis & Hunt, 2017).

The level of teacher interest in the module was also quite high, with a score of 86.19%. This indicates that the E-Module effectively attracts teachers' attention, possibly due to its presentation style, ease of access, or design features that facilitate the delivery of learning materials. The aspect of learning activities received a score of 85.91%, suggesting that teachers found the learning activities supported by this E-Module to be quite effective in enhancing their learning process. This module promotes active learning, aligning with the student-centered learning approach characteristic of 21st-century education (Thiele, Mai, & Post, 2014). Interactive activity-based learning can increase student participation and foster independent learning (Choo, 2007; Tsai, Shen, Chen, Hsu, & Tsai, 2020).

6. CONCLUSION

Expert validation from the media and materials fields indicates that primary school pupils can successfully use the interactive e-modules developed by Smart Applications Creator (SAC). This is due to the application's content being cohesive, the language being understandable, and the information being appropriate, given the students' current academic standing. Overall, the application's impact on elementary school children was positive, as evidenced by their increased attention and the teacher's ability to support their growing critical thinking skills. Thus, the SAC interactive e-module can be an effective learning medium for student understanding as part of efforts toward a green economy. The development of interactive e-modules based on SAC has been proven to improve primary school students' understanding of the concept of a green economy. Based on the findings of this study, it is recommended that the implementation of this e-module be expanded to more schools in different regions to ensure its effectiveness more widely. Additionally, comprehensive training for teachers on the use of SAC is crucial so they can integrate this technology effectively into the learning process. Schools are also encouraged to further promote the integration of digital learning tools into the curriculum, especially in subjects related to environmental education. This e-module

needs to be continuously updated to match technological developments and students' needs. Furthermore, ongoing evaluation and feedback from students and teachers are essential to improve this e-module in the future.

7. IMPLICATIONS

The findings of this study suggest several practical and theoretical implications. First, the successful development and validation of SAC (Smart Apps Creator) interactive e-modules present a promising alternative to traditional teaching materials in environmental education, particularly at the elementary level. The modules' ease of use, interactivity, and ability to run offline make them highly suitable for schools with limited technological infrastructure.

Second, the significant improvement in students' understanding of the green economy highlights the effectiveness of integrating multimedia and gamification principles into early education curricula. This underscores the importance of embedding sustainability-related content into digital learning tools to foster environmental awareness from an early age.

Third, the positive responses from both students and teachers reinforce the notion that digital tools can enhance motivation and engagement when appropriately aligned with learning goals. For policymakers and curriculum developers, this study offers a replicable model for implementing low-cost, scalable, and effective environmental education strategies using mobile learning platforms. Finally, the study encourages further research into the long-term impacts of SAC-based learning on students' behavioral change and environmental activism, as well as its adaptability to other subject areas beyond green economy education.

Funding: This study was supported by the Indonesian Government (Grant number: 0667/E5/AL.04/2024)
Institutional Review Board Statement: The Ethical Committee of the Universitas Darul Ulum Islamic Centre Sudirman, Indonesia has granted approval for this study on 20 June 2024 (Ref. No. 051/A.II/VI/2024).
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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