

The Impact of Green Accounting-Based E-Module to Enhance Accounting Literacy

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Article Info	Abstract
Article history: Received: February 17, 2026 Accepted: April 8, 2026 Published: April 20, 2026 Keywords: Accounting literacy E-modules Green accounting Learning media This article is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License. © 2026 Vidya Karya	In response to the growing importance of environmental accounting, this research focused on creating a contextual-based e-module to bolster students' literacy in green accounting, developed with a Contextual Teaching and Learning (CTL) approach grounded in the local Sasirangan textile industry. Utilizing a Research and Development (R&D) framework through the 4-D model (Define, Design, Develop, and Disseminate), the study rigorously evaluated the digital tool's validity, practicality, and pedagogical impact. Results from expert assessments confirmed the module's high validity at 91.06% (out of a maximum score of 100%), while feedback from educators and students yielded a 93.22% practicality rating (out of 100%), reflecting its ease of implementation. Furthermore, the e-module demonstrated significant efficacy in improving student proficiency, as evidenced by a high-category N-Gain score of 0.78, which indicates that the module is highly effective in a pedagogical context. These findings suggest that the developed media is not only a valid and functional learning resource but also a strategic innovation for embedding sustainability and environmental consciousness into the modern accounting curriculum.
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INTRODUCTION

The low literacy rate in Indonesia, especially among teenagers, has become a concern for the government because it affects the Human Development Index (IPM), which reflects the quality of a country's human resources (Rahmadanita, 2022). Good literacy is crucial for the success of students' learning (Tambun et al., 2023), especially in vocational schools (SMK), which require specialized skills aligned with the advancements of the times and technology, such as computer literacy, technological literacy, moral literacy, information literacy, economic literacy, and accounting literacy (Rahmadanita, 2022). The prevailing gap in students' financial and accounting competence requires strategic improvement, as noted in recent literature (Prasetyo et al., 2024; Rudy et al., 2024).

The proficiency to interpret, evaluate, and apply accounting information for precise decision-making defines the core of accounting literacy (Rahmati et al., 2022). It is also a fundamental skill for accounting students at vocational high schools. Beyond the traditional scope of documenting and synthesizing financial reports, this literacy encompasses ethical financial stewardship within a social and ecological framework. This is achieved through

Green Accounting, a method characterized by the identification, evaluation, and allocation of business-related costs that influence environmental health (Husda, 2024).

As emphasized by Aurelia et al. (2024), vocational education is instrumental in producing highly skilled graduates who are prepared to meet the evolving demands of the global industry. Currently, accountants are not only required to have basic accounting literacy but also to understand sustainability concepts such as CSR and green accounting (Tambun et al., 2023). Green accounting, which has now become a new standard in many companies, is important for vocational school students to understand in order to prepare themselves for the increasing emphasis on sustainability and social responsibility in the workplace. Therefore, integrating green accounting concepts into the vocational school curriculum will help enhance graduates' competitiveness, expand job opportunities, and equip students with skills aligned with current workplace demands.

Green accounting is increasingly recognized as a form of learning that integrates accounting education with a focus on environmental issues. Green accounting is generally taught at the university level and is rarely integrated into secondary school curricula. However, green accounting has great potential as an integrated learning approach that aligns with environmental education and should be introduced and adopted into the vocational high school curriculum. Currently, accounting education in vocational high schools is still limited to basic topics such as basic accounting, electronic spreadsheets, professional ethics, accounting computers, financial accounting, accounting practices for service, trade, and manufacturing companies, institutional accounting, tax administration, and creative products and entrepreneurship (Iskandar et al., 2021; Sholihah & Listiadi, 2021).

Based on a preliminary survey conducted by the authors (2025) at an accredited vocational school, SMKN 1 Banjarmasin, which is a leading school, the results showed that 54.5% of students were unaware of green accounting, and 4.5% of students were completely unfamiliar with the concept. Given this gap, the researchers aim to develop innovative and practical learning materials for students. The development of green accounting-based modules is one of the solutions proposed by the researchers to provide accounting competencies based on green accounting while meeting the demands of the sustainable industry.

As part of the learning package, e-modules are an important element as a learning resource and learning medium for developing the accounting competencies of vocational high schools. E-modules are considered the right solution because they are interesting, interactive, and support effective independent learning (Ramadanti et al., 2021). Digital learning modules encourage a shift toward student-led education, granting learners the flexibility to tailor their study speed to their unique needs. As noted by Ramadanti et al. (2021), this enhancement of learning autonomy is a cornerstone of improved accounting literacy. By adopting these tools, accounting education transcends traditional methods, enabling students to achieve deeper theoretical insights while refining their ability to manage and apply information in professional contexts.

The e-module developed in this research adheres to the pedagogical standards outlined in the Regulation of the Minister of Education and Culture No. 81A of 2013, which mandates that educational content be integrated with the local environment to facilitate autonomous knowledge construction. Central to this design is the CTL approach, a methodology that bridges theoretical concepts with practical, real-world scenarios, thereby allowing learners to apply classroom knowledge to daily life (Febriana & Sakti, 2021). By aligning Green Accounting principles with students' lived experiences and ecological surroundings, this module enables them to perceive accounting as a strategic instrument for mitigating the environmental consequences of corporate operations. This integration directly mirrors the core tenets of contextual learning, which prioritize the synergy between academic material and authentic situational contexts.

While the development of e-modules has gained increasing attention across various educational disciplines, most studies have primarily focused on general accounting learning materials and digital learning effectiveness. Several studies have demonstrated that digital modules can enhance students' engagement and improve accounting literacy compared to traditional printed materials (Ginanjari et al., 2022; Susilo & Harsono, 2021; Suyono & Wijaya, 2021). In addition, other studies confirm that the use of digital learning resources contributes positively to the improvement of accounting literacy among students (Maryam et al., 2023; Pratiwi et al., 2023; Sohilait & Abdurrachman, 2022). However, these studies largely concentrate on conventional accounting topics and rarely integrate sustainability-oriented accounting practices. Consequently, there is very limited research that develops digital learning modules integrating green accounting concepts while simultaneously examining their effectiveness in improving accounting literacy among vocational high school students.

The novelty of this research lies in the integration of green accounting concepts into a digital e-module specifically designed for vocational high school students, which has not been previously addressed in the existing literature. Unlike prior studies that primarily focus on digital modules for general accounting education or environmental accounting at the university level, this study develops a contextualized learning module that combines accounting literacy development with sustainability-oriented accounting practices. Furthermore, the module is structured using the CTL approach to ensure that environmental accounting concepts are connected with students' real-life contexts and local environmental issues. By integrating sustainability values, accounting literacy, and digital learning resources within a vocational education framework, this study provides a new pedagogical model that bridges accounting education with environmental responsibility at the secondary education level.

The primary objective of this research is to investigate the influence of digital modules on students' proficiency in Green Accounting. To achieve this, the study is structured around three core goals: first, to verify the academic and technical validity of the Green Accounting e-module; second, to analyze the practicality and ease of implementation of this digital resource within a classroom setting; and third, to empirically examine how the integration of such e-modules can effectively elevate students' accounting literacy levels. By addressing these objectives, the study aims to provide a validated and functional tool that bridges the gap between traditional accounting education and modern environmental management needs.

METHODS

This investigation adopts a research and development (R&D) framework, specifically implementing the 4-D developmental model pioneered by Thiagarajan in 1974. As detailed by Sugiyono (2023), this systematic process encompasses four critical phases: Define, Design, Develop, and Disseminate. The primary output of this developmental trajectory is a specialized accounting e-module, which integrates green accounting principles to serve as a robust instructional resource in the field of accounting education.

The participant pool comprised a panel of four expert validators: two faculty members from Economic Education (material experts), one specialist from Computer Science Education (media expert), and a professional accounting instructor from SMK Negeri 1 Banjarmasin.

Participants were selected using a purposive sampling technique. The criteria for student participants were 11th-grade accounting pupils at SMK Negeri 1 Banjarmasin who had completed basic accounting cycles, ensuring they possessed the prerequisite knowledge to engage with green accounting concepts. The testing phase involved a small-scale pilot study (n=10) to identify initial technical issues, followed by a limited field trial (n=28) to measure pedagogical efficacy.

The validation instruments for media and instructional materials were developed by synthesizing several established frameworks in instructional media evaluation. The media expert validation instrument was adapted from the framework proposed by [Lestari et al. \(2024\)](#), which emphasizes three main aspects: visual appearance, content integration, and visual communication. These aspects include indicators such as layout organization, color harmony, font readability, design consistency, quality of illustrations and multimedia elements, navigation clarity, and the effectiveness of visual communication in supporting learning experiences.

Meanwhile, the material expert validation instrument was constructed by integrating the evaluation framework proposed by [Baharuddin et al. \(2020\)](#) and [Ramadanti et al. \(2021\)](#). The instrument covers three major dimensions, namely the format and presentation of the e-module, the accuracy and relevance of the material content, and the appropriateness of language use. These dimensions include indicators related to the systematic presentation of learning materials, completeness of supporting components (such as introduction, summaries, and answer keys), accuracy of concepts and examples, and contextual relevance of the materials, as well as clarity, readability, and communicative language suitable for vocational high school students.

The evaluation process for this study was executed across three distinct dimensions: validity, practicality, and effectiveness. The data were collected using several research instruments in the form of validation questionnaires for media experts and material experts, as well as student response questionnaires to assess the practicality of the developed e-module. The media expert validation instrument consisted of indicators related to display, content integration, and visual communication, while the material expert validation instrument included indicators of format and presentation of the e-module, content accuracy, and language aspects. Each instrument contained several assessment items and was measured using a five-point Likert scale ranging from 1 (very poor) to 5 (very good). Prior to being used in the study, the instruments were reviewed by experts to ensure their content validity.

Data regarding the module's validity and practical utility were processed through percentage-based descriptive statistics to determine their respective levels of suitability. The scores obtained from the questionnaires were converted into percentages to determine the level of validity and practicality of the e-module.

To gauge the instructional impact of the e-module, the Normalized Gain (N-Gain) test was employed, quantifying the enhancement in students' accounting literacy. The resulting scores were interpreted using the classification framework established by [Ikhlashul et al. \(2022\)](#). Furthermore, the benchmarks for determining both the validity and practicality of the digital tool were adapted from the standardized criteria proposed by [Irmawati et al. \(2021\)](#), [Syahmani et al. \(2022\)](#), and [Ikhlashul et al. \(2022\)](#).

The research procedures were systematically executed following the four stages of the 4-D development model: Define, Design, Develop, and Disseminate (see Figure 1). The product development in this study follows the 4D model proposed by [Thiagarajan \(1974\)](#), which consists of four main stages: Define, Design, Develop, and Disseminate. Each stage plays a crucial role in ensuring that the accounting e-module based on green accounting concepts is effectively designed to support learning. The diagram below illustrates the complete 4D process, from identifying needs and formulating objectives, through designing and developing the content, to disseminating the final product to users.

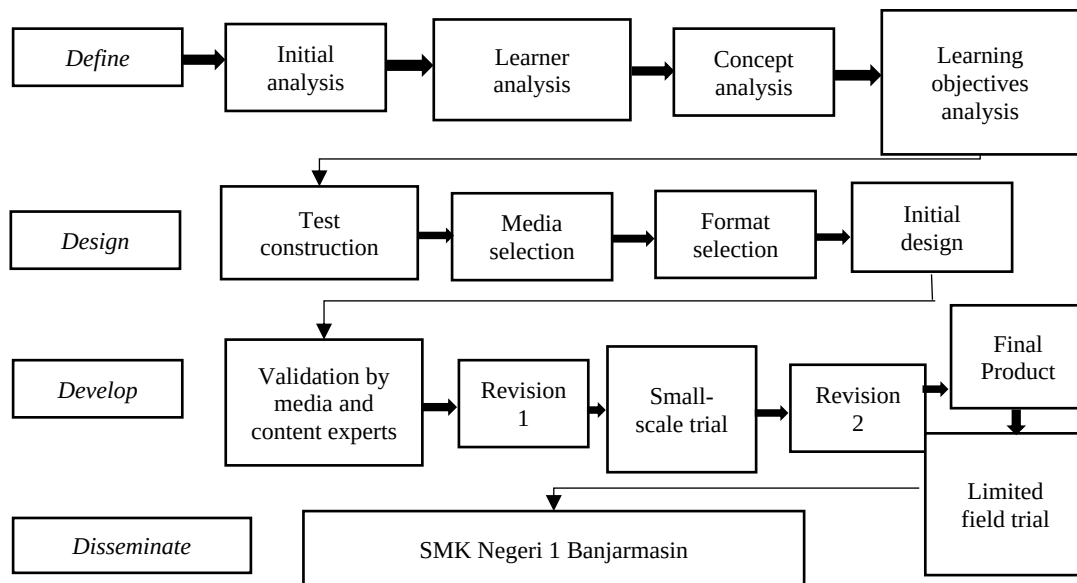


Figure 1 Stages of the 4D development model
Source: Adapted from Thiagarajan, (1974)

The Define stage commenced with a front-end analysis to identify fundamental problems in accounting education, specifically the 54.5% literacy gap in green accounting among vocational students. This phase also involved learner analysis to determine the characteristics of 11th-grade students at SMKN 1 Banjarmasin and task analysis to align green accounting principles with the existing vocational curriculum. Subsequently, the design stage focused on constructing the initial prototype of the e-module. This included selecting the appropriate media format, drafting the instructional materials, and integrating the CTL approach by utilizing the local Sasirangan textile industry as a real-world case study for environmental cost allocation.

The process continued into the development stage, which aimed to produce a refined version of the e-module through iterative evaluation. This stage began with an expert appraisal by four specialized validators to ensure the content's academic validity and the media's technical quality. After incorporating revisions based on expert feedback, the module underwent developmental testing, starting with a small-scale pilot study of 10 students to assess initial usability, followed by a limited field trial with 28 students to measure pedagogical effectiveness using pre-test and post-test instruments. Finally, the dissemination stage was conducted to promote the validated instructional tool. This involved final packaging of the digital resource and distributing the e-module to the accounting department at SMK Negeri 1 Banjarmasin, ensuring it reached the intended educators and students as a functional learning medium for modern sustainability-based accounting.

RESULTS AND DISCUSSION

This research culminated in the development of a specialized accounting e-module, integrating the principles of green accounting through a CTL framework. Guided by the 4D developmental model comprising the define, design, develop, and disseminate phases (Sugiyono, 2023), the study systematically bridged theoretical requirements with practical instructional needs.

The initial Define stage involved a comprehensive situational analysis, encompassing diagnostic evaluations of students, tasks, and core concepts. Front-end investigations, conducted through semi-structured interviews and survey distributions, revealed a critical instructional gap: while educators and students have transitioned toward digital-native resources, there remains a pervasive lack of familiarity with Green Accounting frameworks. This paradox underscores the necessity of the proposed e-module. Furthermore, the learner analysis indicated a significant preference for pedagogical content that resonates with real-world experiences, thereby justifying the selection of a contextual approach. To ensure academic rigor, the task and concept analyses were meticulously mapped to the accounting cycles of service, trading, and manufacturing sectors. These were further aligned with accounting literacy competencies, specifically targeting the fundamental concepts, principles, and structural components of environmental financial reporting (Sugiyono, 2023).

A distinguishing feature of this e-module is its commitment to contextual relevance through the synthesis of global accounting standards and indigenous industry practices. By utilizing the Sasirangan textile production industry, a cornerstone of South Kalimantan's local wisdom, as a primary case study, the module provides students with a tangible environment to observe the identification and recording of environmental costs. This strategic inclusion of local enterprise scenarios not only facilitates a deeper conceptual understanding but also enhances the perceived utility of green accounting in a familiar professional setting. Consequently, the material transcends abstract theory, offering students a pragmatic roadmap for applying sustainable financial practices within their own regional economic landscape.

The design phase focused on translating the conceptual requirements identified in the previous stage into a functional digital prototype. This phase involved four critical sub-processes: test instrument preparation, media selection, format determination, and initial design. Instrument development was meticulously aligned with predefined learning outcomes and accounting literacy competencies to ensure constructive alignment between assessment and content.

Given the students' preference for digital-native resources, an e-module was selected as the primary delivery medium. The creative process leveraged the design capabilities of Canva, which was subsequently integrated into the Heyzine flipbook platform to provide an interactive, page-turning experience. The structural format was anchored in a contextual approach, ensuring that every design element, from linguistic phrasing and word order to the integration of animations, videos, and evaluative components, resonated with real-world scenarios. Notably, the prototype was optimized for mobile accessibility, reflecting a commitment to ubiquitous learning, thereby enabling students to engage with green accounting material without geographical or temporal constraints.

The development stage served as a rigorous quality assurance cycle, where the e-module underwent systematic refinement based on expert feedback to achieve a high degree of academic and technical validity. This phase was bifurcated into validity, practicality, and effectiveness assessments.

Expert validation was conducted through two distinct lenses: Media Validation, a panel of specialists evaluated the module across three core dimensions: visual aesthetics, the seamless integration of instructional content, and the efficacy of visual communication. Material Validation: Subject matter experts assessed the module's academic integrity, focusing on the presentation format, the depth of the green accounting content, and linguistic precision.

Following the incorporation of expert recommendations, the study transitioned to practicality testing. This involved gathering evaluative feedback from a cohort of lecturers and practitioners, who assessed the module based on its format, appearance, and content clarity. Furthermore, student perceptions were analyzed through a comprehensive six-

dimensional framework: user-friendliness, cognitive content management, knowledge space and information presentation, aesthetics, overall functional reliability, and ease of learning. This multi-stakeholder feedback loop ensured that the final product was not only theoretically sound but also practically viable for vocational accounting education.

The final output of this development process is a sophisticated digital instructional tool, characterized by a highly structured and interactive architecture. The e-module is strategically organized to include essential navigational and pedagogical elements, such as a formal cover, an automated table of contents, and comprehensive indices for figures and multimedia assets. To ensure clarity of purpose, the introductory section explicitly outlines learning outcomes and instructional objectives, complemented by a detailed conceptual map and a systematic guide for e-module navigation.

A distinguishing feature of the module's design is the rigorous application of the CTL syntax. Each instructional unit (meeting) is meticulously curated to foster environmental consciousness alongside technical accounting proficiency through the following specialized segments:

- 1) Environmental Integration: The "Greenomics" and "Green Info" sections provide the foundational ecological context, stimulating students' awareness of the intersection between financial reporting and environmental stewardship.
- 2) Contextual Inquiry: The learning flow facilitates active knowledge construction through "Finding" and "Asking" activities, where students engage with the material beyond rote memorization.
- 3) Practical Application: The core of the module lies in its "Case Studies" and "Modeling" sections. These components provide tangible transaction examples—specifically tailored to the Sasirangan production industry—allowing students to witness the practical implementation of green accounting principles in a localized corporate setting.
- 4) Collaborative and Reflective Learning: To enhance social-cognitive development, the module incorporates "Learning Communities" and dedicated "Reflection" phases. These are followed by concise summaries and summative evaluations at the end of each session to solidify the students' conceptual grasp.

The integration of multimedia elements, including high-definition animations and instructional videos, ensures a multi-sensory learning experience. By concluding each module with a specialized glossary and comprehensive evaluation tools, the resource provides a holistic framework that bridges the gap between traditional financial accounting and modern sustainability reporting.

The visual design of the developed e-module is presented in several sections, including the cover design, table of contents, and usage instructions. The front and back covers of the Green Accounting-based e-module are presented in Figure 2. The cover design includes institutional logos, the title of the learning material, the author's identity, and a brief introduction to the concept of green accounting, accompanied by supporting illustrations.

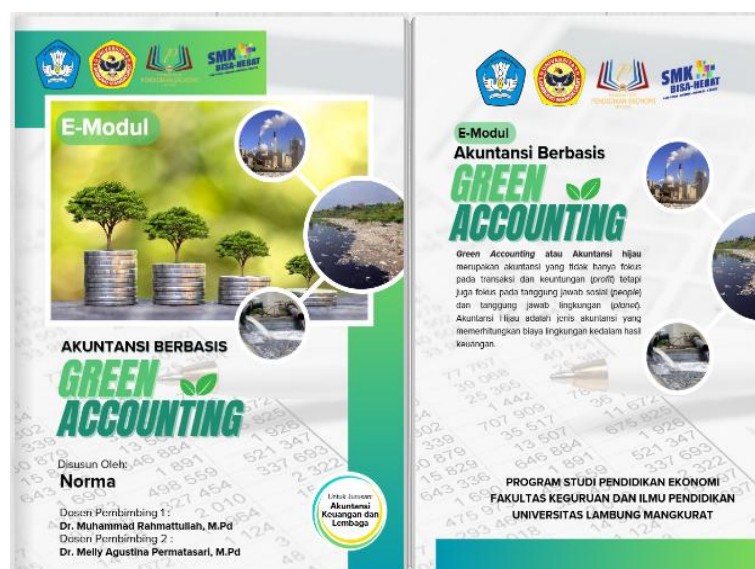


Figure 2 Front and back cover of e-module

The structure of the learning material is organized systematically to help students navigate the content more easily. The table of contents of the e-module is shown in Figure 3, which presents the sequence of topics and subtopics discussed in the module.

iii		iv	
DAFTAR ISI		GREEN ACCOUNTING	
Kata Pengantar	ii	3. Prinsip Pengakuan Kewajiban	23
Daftar Isi	iii	4. Prinsip Pengukuran Nilai	23
Daftar Gambar	v	5. Prinsip Proses Akuntansi Terintegrasi	24
Daftar Video	v	6. Prinsip Pelaporan dan Pengungkapan Terintegrasi	25
Informasi Umum	i	Mayarakat Belajar	26
1. Capaian Pembelajaran	1	Refleksi	27
2. Tujuan Pembelajaran	2	Rangkuman	27
3. Model Pembelajaran Kontektual	3	Evaluasi	28
4. Penjelasan Isi Modul	4	Pertemuan 3 Komponen Green Accounting	29
5. Petunjuk Penggunaan Modul	5	Greenomics	30
6. Peta Konsep	6	Komponen Green Accounting	31
Green Accounting	7	1. Aktiva	31
Pertemuan 1 Konsep Green Accounting	8	2. Liabilitas	34
Greenomics	9	3. Ekuitas	36
Konsep Green Accounting	10	4. Beban/Biaya	36
1. Pengertian Green Accounting	11	Evaluasi & Masyarakat Belajar	38
2. Corporate Social Responsibility (CSR)	13	Refleksi	40
3. Perbandingan Akuntansi Konvensional dan Akuntansi Hijau	14	Rangkuman	40
4. Tujuan Green Accounting	15	Pertemuan 4 Laporan Keuangan Green Accounting	41
5. Syarat Penyajian Informasi Green Accounting	17	Greenomics	42
Mayarakat Belajar	17	Laporan Keuangan Green Accounting	43
Refleksi	18	1. Laporan Kinerja Keuangan Hijau (Laba/Rugi)	43
Rangkuman	18	2. Laporan Posisi Keuangan Hijau (Neraca)	44
Evaluasi	19	Evaluasi & Masyarakat Belajar	50
Pertemuan 2 Prinsip Green Accounting	20	Refleksi	51
Greenomics	21	Rangkuman	51
Prinsip Green Accounting	22	Evaluasi Kompetensi Materi	52
1. Prinsip Sistemabilitas	22	Glosarium	57
2. Prinsip Pengakuan Aset	22	Daftar Pustaka	60
		Biodata Penulis	61

Figure 3 E-module table of contents

To support independent learning, the e-module also provides explanations regarding the structure of the material and instructions for using the module effectively. These explanations and guidelines are illustrated in Figure 4.

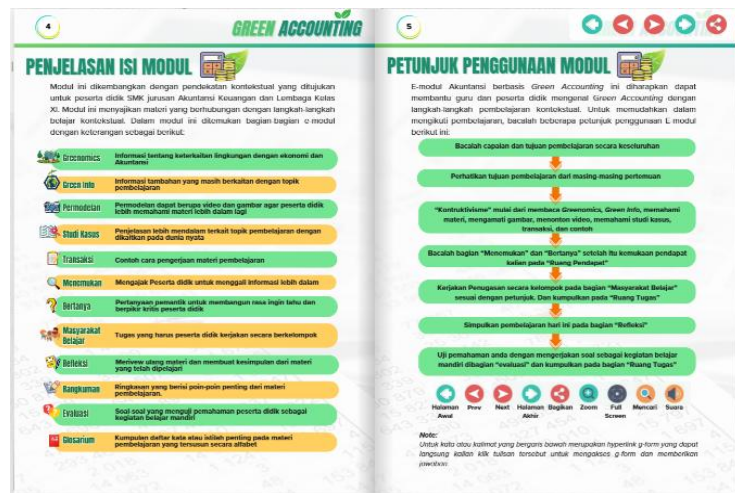


Figure 4 Explanation of e-module content and instructions for use

Adhering to the foundational principles of digital instructional design as proposed by [Laili et al. \(2019\)](#), the developed e-module incorporates comprehensive content orientations and operational guidelines. A critical requirement for effective self-directed learning tools is the inclusion of clear navigational paths and feature explanations to minimize cognitive load. As illustrated in Figure 4, the e-module provides a detailed elucidation of its internal architecture, specifically mapping each pedagogical section to its corresponding learning objective. This is immediately followed by a robust set of instructions for use, which serves as a technical roadmap for students. This instructional framework details the specific functionalities of the interactive features, such as embedded multimedia, flipbook navigation, and self-assessment tools, thereby ensuring a seamless and user-centric learning experience. By providing this structural clarity, the module empowers students to navigate complex green accounting concepts with greater autonomy and precision. A cornerstone of the module's innovative architecture is the "Greenomics" segment, as depicted in Figure 5.



Figure 5 Greenomics, material, modeling, and questioning

This feature serves as an enrichment framework, elucidating the complex interplay between ecological sustainability, economic theory, and accounting practices that

transcend standard curricular boundaries. To mitigate the abstract nature of environmental accounting, the instructional materials are delivered through dynamic animations and communicative linguistics, strategically designed to amplify student engagement and conceptual retention.

Furthermore, the module leverages embedded multimedia to facilitate a multi-sensory learning experience. Specifically, instructional modeling videos sourced from YouTube are integrated directly into the interface; this allows for seamless content consumption, as students can observe practical applications without the cognitive disruption of navigating away from the e-module environment.

To cultivate higher-order thinking skills, the "Questioning" section presents a curated series of stimulatory prompts designed to provoke curiosity and rigorous analytical reflection. This is complemented by an interactive discussion framework, where students can respond to inquiries through embedded hyperlinks. These links provide a direct conduit to Google Forms, enabling real-time data collection and fostering an asynchronous "learning community" that bridges individual study with collaborative academic dialogue. The pedagogical depth of the developed e-module is further enhanced by the "Green Info" feature, as illustrated in Figure 6.



Figure 6 Green info, case studies, and learning communities

This innovative component serves as an auxiliary knowledge repository, providing supplementary insights that contextualize the core accounting curriculum within broader environmental discourse. To bridge the gap between theoretical constructs and professional practice, the module incorporates comprehensive case studies. These scenarios utilize a CTL framework to ground complex accounting topics in tangible, real-world simulations, thereby fostering a more profound conceptual resonance for the learner.

Beyond individual cognition, the e-module strategically incorporates "learning communities" to facilitate collaborative inquiry. These segments are designed as group-based milestones, requiring students to synthesize their collective understanding to solve multifaceted accounting challenges. To streamline the instructional workflow, a dedicated "Assignment Room" is integrated into the interface. This digital gateway utilizes embedded hyperlinks that connect directly to Google Forms, providing a centralized and efficient mechanism for task submission and real-time academic assessment. By embedding these interactive and collaborative elements, the module transcends the limitations of traditional static media, creating a dynamic and interconnected learning ecosystem. The final

component of the instructional cycle, as illustrated in Figure 7, is the Learning Reflection module.

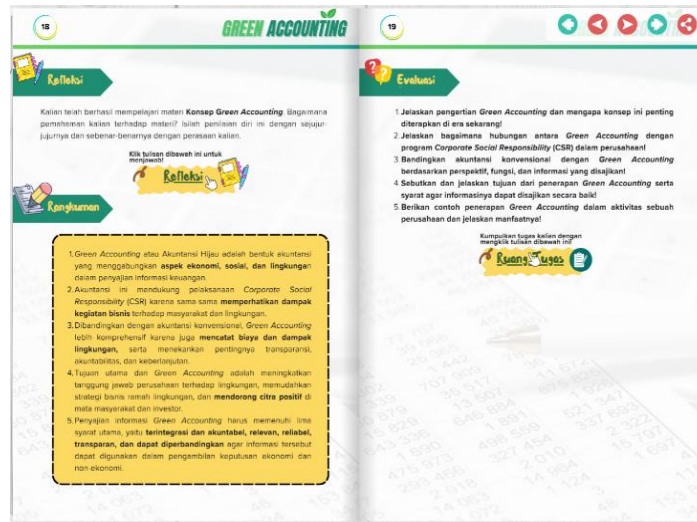


Figure 7 Reflection, summary, and evaluation

This feature is strategically designed to foster metacognitive development, requiring students to critically reappraise the material, pinpoint conceptual ambiguities, and synthesize their own academic conclusions for each session. To ensure a seamless instructional workflow, these reflections are facilitated through interactive hyperlinks that connect students directly to a Google Forms interface, providing a centralized repository for self-assessment data.

To reinforce the learning trajectory, each unit concludes with a comprehensive summary that distills complex accounting principles into fundamental key points, serving as a vital cognitive anchor before students proceed to higher-stakes assessments. Furthermore, the effectiveness of the e-module is measured through a summative evaluation at the end of each meeting. Unlike traditional multiple-choice formats, these assessments utilize essay-based inquiries to gauge deep understanding and critical application of green accounting concepts. Students are required to submit their responses through a dedicated "Assignment Room," an integrated digital portal that streamlines the submission process and ensures accountability in the pedagogical exchange. As illustrated in Figure 8, the e-module bridges theoretical accounting with practical application through specialized transaction modeling.

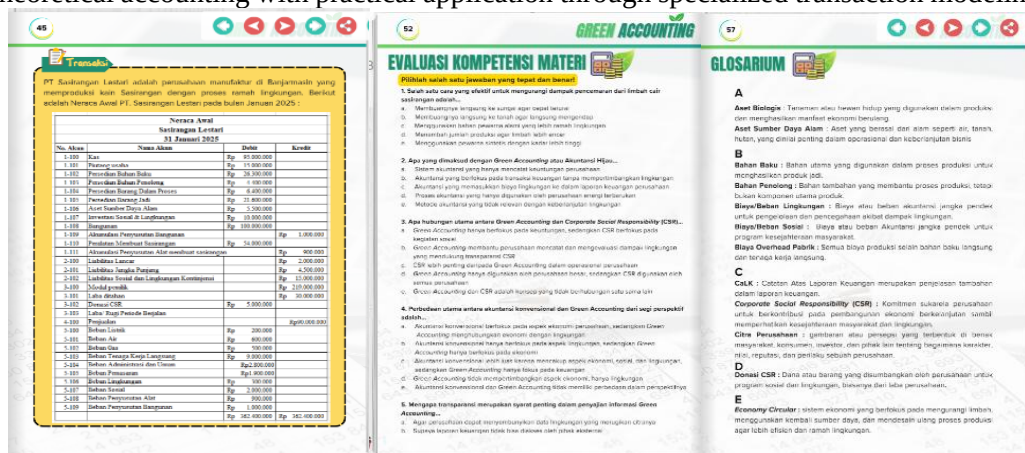


Figure 8 Example transaction, material competency evaluation, and glossary

A cornerstone of this instructional design is the integration of South Kalimantan's indigenous industry, specifically centering on Sasirangan textile production. By utilizing a

manufacturing firm within the Sasirangan sector as a primary case study, the module elucidates the intricate financial recording of raw materials, auxiliary inputs, and direct labor costs. This localized context not only reinforces the technicalities of manufacturing accounting but also fosters a deeper appreciation for the economic value of traditional heritage.

To ensure comprehensive mastery of the material, the e-module incorporates a summative competency evaluation comprising rigorous multiple-choice inquiries that span the entire curriculum. This is complemented by an alphabetical glossary, a curated lexicographical resource that provides precise definitions of specialized terms, thereby supporting student autonomy in navigating complex accounting terminology.

Following the iterative cycles of the Define, Design, and Develop stages, the research culminated in the dissemination phase. The transition to this final stage was predicated on the e-module being empirically validated as a valid, practical, and effective instructional tool through expert scrutiny and field trials.

To facilitate widespread adoption and minimize barriers to entry, the dissemination strategy involved the distribution of promotional posters featuring embedded Quick Response (QR) codes. This digital gateway allows educators and learners to access the e-module instantly via mobile scanning, reflecting a commitment to integrating educational technology and ensuring ease of access. The empirical foundations justifying this dissemination, specifically the quantitative results of the validity assessments, are meticulously detailed in Table 1.

Table 1 Validity test results

Validity	Media Expert			Subject Matter Expert		
	1	2	3	1	2	3
Average Aspect	4.42	4.70	4.50	4.73	4.44	4.54
Average validity	4.54			4.57		
Validity Results	4.55					
Percentage (%)	91.06					
Criteria	Very Valid					

The rigorous evaluation of the e-module's structural and pedagogical quality was substantiated through formal validation by subject matter and media specialists. Quantitative analysis of the validity test results yielded a high mean score of 4.55, corresponding to a comprehensive percentage of 91.06%. According to the standardized evaluation benchmarks, these metrics classify the developed e-module within the "Highly Valid" category. This exceptionally high level of expert consensus confirms that the module's instructional architecture, linguistic precision, and multimedia integration are robust and ready for pedagogical implementation. Following this technical validation, the research proceeded to evaluate the module's functional utility in a real-world educational setting. The subsequent findings regarding the practicality test derived from both educator and student perspectives are systematically detailed in Table 2.

Table 2 Practicality test results

Practicality	Mean	Percentage (%)	Criteria
Teachers and Lecturers' Responses	4.66	93.25	Very Practical
Small-Scale Trial	4.85	97.06	Very Practical
Limited Field Trial	4.47	89.50	Very Practical
Practical Results	4.66	93.22	Very Practical

The functional utility of the Green Accounting e-module was rigorously assessed through a comprehensive practicality test, synthesizing evaluative feedback from a multi-

stakeholder perspective. This assessment integrated the perspectives of academic lecturers and practitioners with the experiential feedback from students across two distinct trial phases. Quantitative analysis of these response questionnaires yielded a substantial mean score of 4.66, corresponding to an overall achievement of 93.22%. According to established pedagogical benchmarks, these empirical results categorize the developed e-module as "highly practical" for instructional implementation. This high level of acceptance underscores the module's seamless navigation, linguistic clarity, and operational suitability within the vocational accounting curriculum. Following the confirmation of its practical viability, the study proceeded to measure the actual learning gains through an effectiveness analysis. The comparative data between pre-test and post-test outcomes, illustrating the module's impact on student performance, are systematically presented in Table 3.

Table 3 Pre-test and post-test results

Test	Min	Max	Mean
Pre-Test	20	75	54.46
Post-Test	60	100	88.93

The empirical evaluation of the e-module's effectiveness revealed a substantial enhancement in students' academic performance. Specifically, the data indicate that accounting literacy levels underwent a significant upward trajectory, rising from a baseline mean of 54.45 (Moderate) in the pre-test to a robust 88.93 (High) following the instructional intervention.

This marked improvement underscores the pedagogical potency of integrating green accounting principles within a digital, contextual framework. To further quantify the magnitude of this academic growth and ensure the statistical rigor of the findings, the pre-test and post-test datasets were subjected to a N-gain analysis. This metric provides a standardized measure of the learning gains achieved, accounting for the initial knowledge variance among students. The comprehensive results of the N-Gain calculations, illustrating the precise scale of the literacy enhancement, are systematically detailed in Table 4.

Table 4 N-gain test results

Pre-Test	54.46
Post-Test	88.93
N-gain	0.78
Criteria	Tall
N-gain %	78.64
Interpretation	Effective

To evaluate the magnitude of the e-module's impact on student learning, the research utilized the N-Gain test. The analysis yielded an N-Gain score of 0.78, which, according to established pedagogical benchmarks, is classified within the "High" criteria with an "Effective" interpretation.

This robust statistical result provides empirical evidence of a substantial upward shift in students' accounting literacy between the pre-instructional and post-instructional phases. The high gain score underscores the efficacy of the green accounting-based e-module as a transformative pedagogical tool, capable of significantly bridging knowledge gaps in environmental financial reporting. Beyond the aggregate growth, a more granular assessment was conducted to identify specific areas of improvement. The N-Gain results categorized by accounting literacy competencies detailing the module's performance across various cognitive and technical domains are systematically presented in Table 5.

Table 5 N-gain test results based on accounting literacy competencies

Competence	Pre-Test	Post-Test	N-gain	Criteria	N-gain %	Interpretation
A	20.50	27.33	0.91	Tall	91.11	Effective
B	25.80	26.20	0.85	Tall	85.25	Effective
C	11.44	22.56	0.67	Currently	67.11	Quite Effective

The results presented in Table 5 indicate that the implementation of the Green Accounting-based e-module improved students' accounting literacy across all competency components. Competencies A and B achieved N-Gain scores of 0.73 and 0.75, respectively, which fall into the effective category.

However, competency C, which focuses on the financial reporting component, obtained a slightly lower N-Gain score of 0.67, categorized as quite effective. This relatively lower improvement may be attributed to the higher level of complexity associated with financial reporting concepts in accounting. Students are required to understand technical procedures such as recording, classification, and preparation of financial statements that incorporate environmental cost components. In addition, the limited practice time during the learning process may have reduced opportunities for students to fully master these technical aspects.

The findings of this study demonstrate that the Green Accounting-based e-module meets the criteria of validity, practicality, and effectiveness as a learning resource to improve students' accounting literacy. The expert validation results indicate that the module possesses strong pedagogical and technical quality. This finding supports the instructional design principles proposed by [Laili et al. \(2019\)](#), which emphasize that digital learning modules should be accessible, flexible, and capable of accommodating diverse student learning needs. The design of the developed e-module incorporates structured navigation, interactive features, and multimedia integration, which collectively facilitate independent learning and improve user engagement.

The high validity results are also consistent with previous studies, indicating that e-modules can effectively support autonomous learning. For example, research by [Denis and Hakim \(2021\)](#) found that digital learning modules significantly contribute to the development of student independence in learning. Similarly, [Lastris \(2023\)](#) reported that well-designed e-modules enhance student motivation by presenting learning materials in a structured and engaging digital format.

In addition to validity, the developed e-module demonstrated high practicality based on student responses. The interactive features embedded within the module, such as prompt questions, self-assessment tools, and integrated multimedia elements, provide students with opportunities to actively engage with the learning material. These findings align with the results of research conducted by [Larasati et al. \(2020\)](#); [Tomczyk et al. \(2020\)](#); [Ramdana et al. \(2026\)](#), which showed that digital learning media can facilitate self-evaluation and encourage students to monitor their own learning progress.

The effectiveness analysis using the N-Gain test indicates that the implementation of the e-module significantly improved students' accounting literacy. This result supports previous findings by [Febriana and Sakti \(2021\)](#); [Hannan & Eynon, \(2025\)](#), who reported that digital modules can improve learning outcomes when supported by interactive features and contextual learning materials. Similarly, [Mijaya et al. \(2021\)](#) demonstrated that contextual learning approaches embedded in e-modules can generate high N-Gain scores and enhance students' conceptual understanding.

However, the results also indicate that the financial reporting competency component achieved a slightly lower N-Gain score compared to other competencies. This finding is consistent with the observation of [Iskandar et al. \(2021\)](#), who noted that students often experience difficulties in mastering technical accounting procedures such as financial reporting and the preparation of environmental cost statements. The complexity of financial

reporting concepts requires more intensive practice and deeper analytical understanding. Therefore, additional practice exercises or extended instructional time may be necessary to strengthen students' mastery of this component.

Overall, the results suggest that integrating green accounting concepts into digital learning resources can effectively bridge the gap between theoretical accounting knowledge and sustainability-oriented financial reporting practices. By incorporating multimedia explanations, interactive exercises, and contextual examples, the developed e-module provides a learning environment that supports both conceptual understanding and practical application.

The findings of this study offer several practical implications for educators and curriculum developers. For teachers, the developed e-module can serve as a supplementary learning resource that supports independent learning and improves student engagement in accounting classes. The interactive structure of the module allows teachers to integrate digital learning activities into classroom instruction while still maintaining flexibility in teaching methods. For curriculum developers and educational institutions, the Green Accounting-based e-module provides a model for integrating sustainability concepts into accounting education. Incorporating environmental accounting topics into vocational curricula can help prepare students to understand emerging financial reporting practices related to environmental responsibility and sustainable business operations.

Despite the positive findings, this study has several limitations that should be considered. First, the implementation of the e-module was conducted in a single educational institution, which may limit the generalizability of the findings to other educational contexts. Differences in student characteristics, institutional resources, and technological infrastructure may influence the effectiveness of digital learning tools. Second, the duration of the learning intervention was relatively limited, which may have affected the extent to which students were able to fully master complex accounting competencies, particularly in the financial reporting component.

CONCLUSION

This study successfully developed and evaluated a green accounting-based e-module using a research and development framework. The results indicate that the developed learning resource meets the criteria of validity, practicality, and effectiveness. Expert validation confirmed that the module possesses strong pedagogical and technical quality, while student responses demonstrated that the module is practical and easy to use in the learning process. Furthermore, the effectiveness analysis showed that the implementation of the e-module significantly improved students' accounting literacy.

The findings of this study also provide important pedagogical and practical implications for accounting education, particularly in vocational institutions. The integration of green accounting within a digital learning module demonstrates that sustainability-oriented accounting concepts can be effectively introduced at the secondary education level, not only at universities as commonly practiced. From a pedagogical perspective, the developed e-module offers an innovative instructional resource that supports contextual and technology-based learning, enabling educators to enhance students' accounting literacy while simultaneously fostering environmental awareness and responsible financial decision-making. Practically, the module can serve as a complementary learning resource for vocational accounting curricula and contribute to preparing students with competencies aligned with the increasing global demand for sustainability-oriented accounting practices. Beyond these findings, this study contributes to the development of sustainability-oriented learning resources in accounting education. The green accounting-based e-module can serve as a model for designing digital learning materials that integrate environmental sustainability concepts with financial accounting practices.

Future research is recommended to expand the implementation of this learning tool across multiple institutions and diverse educational settings to enhance the generalizability of the findings. In addition, further studies should explore strategies to improve students' understanding of financial reporting components, for example, by incorporating more interactive exercises, simulation-based learning activities, or extended practice sessions.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, MR and N; methodology, N and MAP; formal analysis, N and AS; investigation, N and MR; data curation, AS; writing preparation of the original draft, N; writing review and editing, MAP and ES; supervision, MR. All authors have read and agreed to the published version of the manuscript.

AI DISCLOSURE STATEMENT

The authors used ChatGPT during the preparation of this work for language refinement and clarity improvement. After using the tool, the authors thoroughly reviewed and edited the content as needed and take full responsibility for the content of the publication. The authors declare that this research was prepared, researched, analyzed, and validated without the aid of artificial intelligence (AI) techniques.

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