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DEVELOPING A RENEWABLE ENERGY-THEME ENGLISH-SPEAKING MODULE FOR SENIOR HIGH SCHOOL STUDENTS

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Abstract
Developing students' speaking competence remains challenging in English language teaching, particularly when lessons lack authentic contexts connecting learning to real-world issues. This study aimed to design and validate a web-based e-module integrating renewable energy themes to support Grade XI students' speaking skills while fostering ecological awareness. Guided by Content-Based Instruction and Eco-linguistics principles, this Research and Development (R&D) study followed the Borg and Gall model, conducted in two senior high schools (SMA N.1 Hinai and SMA N.1 Gebang) in Langkat, North Sumatra. Data were collected through expert validation sheets, questionnaires, classroom observations, and semi-structured interviews involving 60 students and 8 English teachers, then analyzed using descriptive statistics and thematic analysis. The development process encompassed expert validation, small-scale trials, and classroom implementation. Expert reviews confirmed high validity across content, language, and instructional technology dimensions (M = 90.35%, "highly feasible"). Practicality tests with students and teachers indicated the module was user-friendly, engaging, and contextually relevant (M = 87.6%). Findings suggest that embedding sustainability themes within interactive digital modules enriches language learning by providing meaningful contexts and enhancing engagement. This study contributes theoretically by bridging Content-Based Instruction with Eco-linguistic perspectives, and practically by offering an innovative model for English language teaching aligned with Sustainable Development Goals (SDGs). Future research should explore longitudinal impacts and adapt this approach across diverse educational contexts to maximize broader relevance and effectiveness.

Keywords: CBI, e-module, renewable energy, speaking skills, sustainability

Introduction

English speaking skills are among the essential competencies in English language learning, crucial for students to communicate effectively (Suprayetno et al., 2022). However, many students struggle to achieve speaking fluency. This skill not only reflects language proficiency but also serves as a key indicator of success in foreign language education (Sholihah et al., 2024). According to Bendeck Soto et al. (2020), factors such as lack of motivation, less interactive teaching methods, and minimal use of real-life contexts in learning contribute to students' low speaking proficiency. These challenges highlight the need for innovative approaches that connect language learning with meaningful, real-world contexts.

The Content-Based Instruction (CBI) approach, when combined with eco-linguistic principles, has proven effective in improving language skills by integrating thematic content into the learning

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process (Rahmayani & Asrizal, 2024). Interesting and contextual topics, such as environmental issues, can enhance students' engagement, motivation, and participation in English learning (Fikni et al., 2024). From an eco-linguistic perspective, language is not separate from the social and ecological environment; therefore, incorporating themes like renewable energy into language teaching can raise environmental awareness while simultaneously developing students' communication skills (Putra, 2023; Lestari et al., 2024).

Integrating renewable energy topics into English language learning can increase students' environmental awareness and provide authentic contexts that enrich their speaking skills. From an eco-linguistic viewpoint, language education that reconnects students with their ecological surroundings contributes to the development of better communication skills and can make learning more engaging and effective (Sari & Nurhikmawati, 2017; Mbete, 2015). When incorporated into English speaking instruction, environment-based education not only enriches the learning context but also enhances speaking proficiency through real-world stimuli (Abdallah et al., 2024).

The use of interactive web-based learning media, such as e-modules, has been shown to significantly improve learning outcomes and foster effective independent learning (Nasution et al., 2024; Rahmayani & Asrizal, 2024). Digital modules designed with thematic content such as renewable energy align with the principles of sustainable education and globally contextualized learning (Hasrina et al., 2024). Although studies have confirmed the benefits of contextualized and sustainability-oriented language learning, little attention has been given to developing interactive digital modules that integrate renewable energy themes into speaking instruction. Research by Muhammad et al. (2023) highlights the importance of innovation in English teaching methods that integrate global issues within the 21st-century education context.

This study seeks to bridge that gap by developing and validating an interactive web-based e-module for English speaking skills grounded in renewable energy themes. The novelty of this research lies in integrating CBI with eco-linguistic perspectives via a digital platform to promote both communicative competence and ecological awareness. Specifically, the study aims to (1) design a web-based e-module for Grade XI students that integrates renewable energy content and (2) evaluate its validity and practicality through expert reviews and classroom trials. Accordingly, this research is guided by the following question: How valid and practical is an interactive renewable energy-based e-module in supporting the development of students' speaking skills in senior high school English learning in Langkat?

Literature Review

This review outlines key perspectives that frame the study, including challenges in speaking fluency, the role of Content-Based Instruction (CBI), eco-linguistic and sustainability themes in ELT, and the integration of interactive digital modules. These areas are highlighted because they not only inform innovative pedagogical practices but also demonstrate the relevance of linking language learning with contemporary global issues such as sustainability.

English speaking skills in language learning

English speaking skill is a critical component in language learning, yet many students continue to face persistent challenges in achieving fluency. Factors such as limited motivation, lack of interactive pedagogy, and the absence of real-world contexts often hinder students' speaking development

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(Bendeck Soto et al., 2020). This indicates the need for innovative pedagogical approaches that provide authentic, meaningful contexts for communication.

Content-based instruction (CBI) as a pedagogical approach

To address this, one approach that has gained growing attention is Content-Based Instruction (CBI), which integrates thematic content rather than isolated grammar or vocabulary into language lessons. When combined with Eco linguistic perspectives, which emphasize the role of language in shaping ecological awareness, CBI offers a more meaningful and context-rich framework for language learning. Recent findings by Tang (2024) demonstrated that English language instruction grounded in Eco linguistic themes significantly improved speaking performance and environmental consciousness among learners, with students reporting enhanced interest and motivation in sustainability topics (Shaik et al., 2024).

Ecolinguistics and sustainability themes in ELT

The integration of sustainability and environmental themes into English Language Teaching (ELT) aligns well with the principles of Education for Sustainable Development (ESD) as promoted by the United Nations' Sustainable Development Goals (SDGs). A systematic review by Yu et al. (2024) in Sustainability highlighted that such integration not only fosters language proficiency but also promotes global citizenship, environmental responsibility, and critical thinking although the study also noted the importance of teacher readiness and context-appropriate materials (Yu et al., 2024). Embedding renewable energy topics, in particular, allows students to engage with real-world environmental issues that are relevant to both their local and global communities, thus enhancing their communicative competence and ecological literacy.

Interactive digital modules in language learning

To support this pedagogical shift, the use of interactive web-based e-modules has emerged as a powerful tool. Digital learning platforms enable students to engage independently and interactively with language material at their own pace. Research by Nasution et al. (2024) and Rahmayani and Asrizal (2024) found that e-modules significantly improved student learning outcomes and motivation, especially when they featured thematic and multimedia-rich content. The findings are echoed by E3S Web of Conferences (2024), where students demonstrated increased retention and participation when renewable energy materials were embedded into the language learning modules (Shaik et al., 2024).

Contextual topics and speaking fluency

Authentic and contextual topics, such as renewable energy, have been shown to improve speaking fluency by helping students personalize speech. Contextual themes help students to personalize their speech, use vocabulary meaningfully, and develop their ideas within real-world frameworks. John and Yunus (2021) found that students in tourism and environmental studies were more confident and fluent when asked to speak on topics they found relatable and relevant. This supports the idea that language learning is most effective when content is grounded in the learners' social and environmental realities (Kim, 2020).

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Summary and research gap

Taken together, the integration of Eco linguistic principles, sustainability themes, and web-based interactive learning modules forms a robust theoretical and empirical foundation for enhancing speaking skills among senior high school students (Kuusalu & Stibbe, 2025). However, few studies have specifically developed web-based e-modules that embed renewable energy themes to strengthen speaking instruction. Addressing this gap, the present study develops and validates such a module, offering both pedagogical innovation and a contribution to sustainability-oriented language education. This aligns English learning with broader goals of environmental education and offers a solution to the persistent challenges of low speaking proficiency in secondary education. Therefore, developing an interactive web-based e-module that incorporates renewable energy content stands as a relevant, innovative, and pedagogically sound response to both educational and environmental imperatives (Kazazoglu, 2025).

Methodology

Research design and approach of the study

This study followed a Research and Development (R&D**)** design, adopting the Borg and Gall (1983) model, which remains relevant in contemporary educational research (Samsu, 2021). Subsequent adaptations, such as Untoroseto and Triayudi (2023), also affirm the suitability of R&D for developing digital learning materials, including blended and web-based modules. In this study, the R&D procedure was carried out through several adapted stages (Sahayu et al., 2025). The preliminary stage involved a needs analysis using classroom observations, semi-structured interviews with English teachers, and student questionnaires to identify challenges in speaking instruction and the potential relevance of renewable energy themes.

The planning stage included formulating learning objectives, aligning selected Grade XI curriculum topics with speaking competencies, and designing the initial outline of the e-module. During the product development stage, the researchers created the prototype of the web-based e-module by integrating Content-Based Instruction (CBI) and ecolinguistic principles with multimedia features. The validation stage consisted of expert reviews: content and language experts assessed accuracy and curriculum alignment, while instructional technology experts evaluated interface design, interactivity, and accessibility. These assessments were conducted using structured validation sheets with Likert-scale items. Finally, practicality testing was conducted through small-scale classroom trials, where 60 students and 8 teachers used the module and provided feedback through questionnaires on usability, clarity, and engagement, supplemented by researcher observation checklists documenting classroom interaction and learner responses.

Quantitative data were obtained from expert validation scores (covering content accuracy, language appropriateness, and technological feasibility) and from student and teacher questionnaire results (measuring ease of use, clarity, and engagement). Qualitative data were gathered from interview transcripts with teachers, open-ended questionnaire responses from students, and classroom observational notes describing learner participation and interaction. This combination of data sources ensured that the developed e-module was systematically refined and rigorously assessed for its validity and practicality before being recommended for classroom application.

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Research site and participants

The research was conducted in two public senior high schools in Langkat, North Sumatra: SMA Negeri 1 Hinai and SMA Negeri 1 Gebang. These schools were purposively selected because they represent public schools in semi-urban areas where students often face challenges in English speaking proficiency, yet have sufficient technological infrastructure to support web-based learning. Both schools also follow the same national curriculum, which ensured consistency in aligning the e-module with Grade XI learning objectives.

A purposive sample of 60 Grade XI students (30 from each school) and 8 English teachers was selected. The choice of Grade XI students was based on curricular considerations, as the targeted speaking competencies such as giving opinions, describing phenomena, participating in discussions, and explaining cause and effect are emphasized in the Grade XI syllabus. Teachers were included as participants because of their pedagogical expertise and practical insights regarding classroom implementation. The number of 60 students was considered sufficient for gathering diverse yet manageable feedback during module trials, while 8 teachers provided balanced perspectives for expert and practitioner validation.

Data collection and analysis

Data were collected using a mixed-methods approach, combining quantitative and qualitative techniques to provide a comprehensive evaluation of the e-module's validity, and practicality. The use of mixed methods was intended to obtain numerical evidence of feasibility while also capturing participants' experiences and perspectives, thus ensuring a more holistic evaluation (Creswell & cresswell, 2018).

For qualitative data, three instruments were used. First, structured classroom observations were conducted to document how students interacted with the e-module in terms of participation, fluency practice, and engagement. The observation checklist was adapted from Borg and Gall's (1983) evaluation framework, focusing on instructional clarity, learner interaction, and use of multimedia resources. Second, semi-structured interviews were carried out with English teachers and selected students. The interviews explored their perceptions of the module's relevance, usability, and contribution to speaking practice. The interview guide was formulated based on themes identified in previous studies on digital module development (Rahmayani & Asrizal, 2024). Third, open-ended questions in the student questionnaire provided opportunities for learners to express detailed feedback in their own words, complementing quantitative results with richer insights.

For quantitative data, a Likert-scale questionnaire was administered to 60 students and 8 teachers to measure perceptions of content clarity, multimedia appeal, ease of navigation, and contextual relevance. The questionnaire items were adapted from validated e-learning evaluation frameworks (Alqahtani & Rajkhan, 2020; Joshi et al., 2015), and adjusted to fit the objectives of this study. For example, items measuring multimedia appeal asked students to rate the usefulness of videos, images, and interactive quizzes for their speaking practice. Expert validation sheets were also used to assess the module's validity. Content and language experts evaluated accuracy, curriculum alignment, and linguistic appropriateness, while instructional technology experts reviewed interface design, accessibility, and multimedia interactivity. These instruments employed a five-point Likert scale, and their construction followed procedures outlined by Sugiyono (2019) for R&D studies.

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Data collection procedures followed the R&D cycle. During the preliminary stage, needs analysis data were gathered through observations, interviews, and questionnaires to inform module design. In the development stage, expert validation data were collected to refine the prototype. In the practicality testing stage, classroom trials were observed, and students and teachers completed questionnaires to assess usability and engagement. The researcher, who has professional training in English education and prior experience in digital material development, directly facilitated the data collection, ensured ethical conduct, and maintained consistency across both school sites. Triangulation was applied by cross-verifying data from different sources—expert reviews, student responses, teacher feedback, and classroom observations—thus strengthening the validity of the findings (Creswell & Creswell, 2018).

Product validity testing

Product validity testing was conducted during the development stage of the ADDIE model and included both expert validation and limited student trials. In the expert validation phase, content and language specialists assessed the alignment of the module content with learning objectives, the accuracy of renewable energy information, and the appropriateness of the language level for Grade XI learners (Sugiyono, 2019).

Instructional technology experts further evaluated technical aspects such as interface design, multimedia interactivity, and accessibility (Pradnyawati & Rati, 2023). The validation instrument employed a 5-point Likert scale covering content feasibility, presentation, language quality, and graphical design. The mean scores were then converted into percentages and interpreted according to established eligibility criteria (Joshi et al., 2015), with the e-module considered valid if it achieved a score of at least 80% of the maximum possible score. Following expert validation, a small-scale trial was conducted with 15 students who were not part of the main research sample. This trial aimed to examine the clarity of instructions, ease of navigation, and overall engagement, and the feedback gathered at this stage was used to refine the module before full-scale implementation.

Data analysis

Quantitative and qualitative data were analyzed systematically to provide a comprehensive evaluation of the developed e-module. For quantitative data, expert validation results and questionnaire responses were analyzed descriptively. The scores from each validator were summed, divided by the total possible score, and then converted into percentages. Following Arikunto's (2013) criteria, results were categorized as "Highly Feasible" (≥ 80%), "Feasible" (60–79%), "Moderately Feasible" (40–59%), or "Not Feasible" (< 40%). Student and teacher questionnaire responses were also processed by calculating mean scores and standard deviations to identify patterns of agreement and areas for improvement. This descriptive statistical approach was chosen to simplify interpretation while maintaining objectivity, as recommended in applied R&D research (Sugiyono, 2019).

For qualitative data, a thematic analysis was conducted using Braun and Clarke's (2006) six-step framework. First, the researcher familiarized themselves with the data by transcribing interviews and reading observational notes multiple times. Second, initial codes were generated to capture meaningful segments related to usability, clarity, and engagement. Third, codes were collated into potential themes such as "student engagement," "usability challenges," and "curricular relevance." Fourth, these themes were reviewed by comparing them against the coded extracts and the entire dataset. Fifth, themes

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were defined and refined to ensure clarity and distinctiveness. Finally, the findings were reported with illustrative quotes to provide authentic participant voices. This process allowed qualitative insights to complement quantitative findings, giving a fuller picture of the module's strengths and limitations. The role of the researchers was central in both analyses. As lecturers in English education with prior experience in instructional design, they brought both pedagogical expertise and contextual understanding into the analysis process. Data interpretation was guided by established frameworks to minimize bias and enhance reliability.

To ensure the trustworthiness of qualitative findings, Lincoln and Guba's (1985) criteria were applied. Credibility was established through data triangulation across interviews, observations, and open-ended questionnaire responses. Dependability was enhanced by maintaining an audit trail of coding decisions and analysis steps. Confirmability was addressed by peer debriefing with fellow researchers to minimize personal bias. Transferability was supported by providing detailed descriptions of the research context, participants, and module design, enabling readers to assess the applicability of findings to other contexts.

Results

This section presents the findings of the study in line with its stated purposes and research question: How valid and practical is an interactive renewable energy-based e-module in supporting the development of students' speaking skills in senior high school English learning in Langkat? Accordingly, the findings were organized into two subsections. The first reports on expert validation results addressing the validity of the e-module, while the second presents the outcomes of practicality testing with students and teachers.

The needs analysis revealed that students often struggled to express complex ideas fluently in English, while teachers emphasized the importance of contextualized materials aligned with the curriculum. Both groups expressed interest in integrating environmental themes, especially renewable energy, as a meaningful context for language learning. These insights shaped the module's content, speaking activities, and multimedia design.

The speaking materials designed in this study were limited to selected topics from the Grade XI English syllabus that are thematically aligned with renewable energy and communicative learning objectives. These topics included giving opinions, describing environmental phenomena, participating in group discussions, and explaining cause and effect.

This structure was designed to promote fluency, accuracy, and engagement through multimedia-assisted tasks embedded in the e-module. The selected speaking topics are aligned with the national curriculum and support both language development and environmental literacy (Kemendikbud, 2022). The structured integration of thematic content in speaking lessons also reflects best practices in Eco linguistic and content-based instruction, which have been shown to enhance communicative competence and contextual understanding (Rahmayani & Asrizal, 2024); (Tang, 2024).

The final product of this research is of an interactive web-based e-module integrated into an English learning model with renewable energy "Let's Talk Green – Developing Speaking Skills through Renewable Energy Topics". Designed with a clean, eco-themed layout, the module integrates text, visuals, audio, and video to support communicative learning. The module is organized into eight sessions, each focusing on different aspects of speaking practice and renewable energy awareness. Its units are aligned with the Grade XI English syllabus, focusing on speaking activities such as giving

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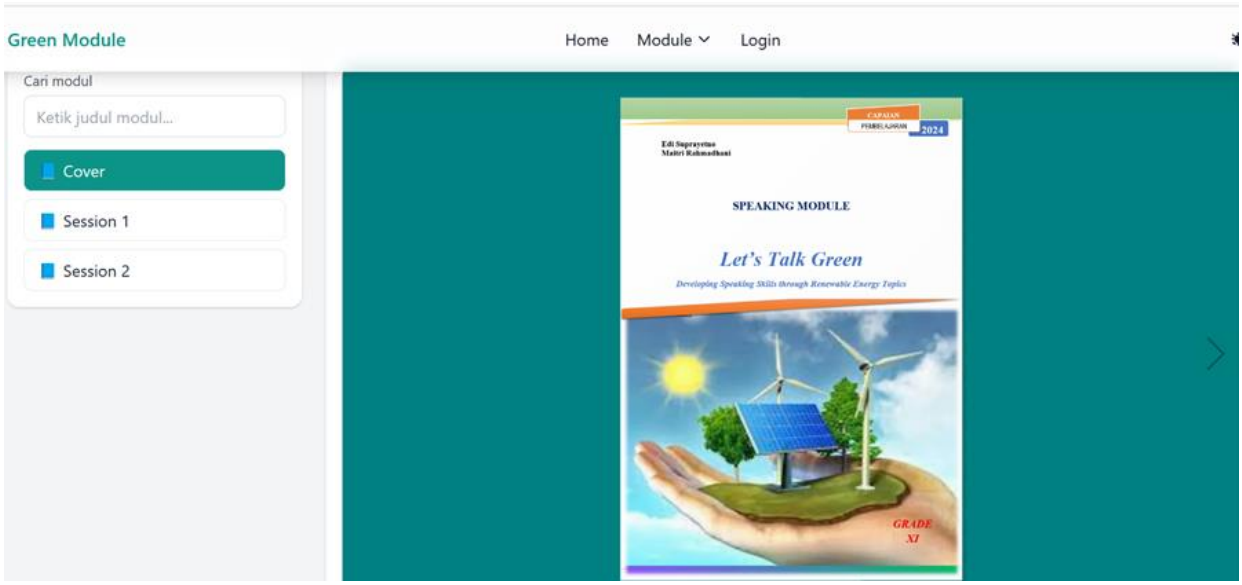
opinions, describing environmental phenomena, participating in discussions, and explaining cause-effect relationships as shown on the following figure.

Figure 1. *Dashboard of the E-module*



The web-based dashboard of the *Speaking Module: Let's Talk Green* was developed with a clean, eco-themed design that visually reinforces its focus on renewable energy. The homepage features intuitive navigation with clearly structured menus that guide learners to each session, including access to videos, quizzes, interactive discussions, and project instructions. Multimedia resources such as infographics, embedded videos, and audio recordings are integrated to support diverse learning styles and enhance student engagement. The use of consistent icons, balanced colour schemes, and responsive layouts ensures that the module remains accessible, visually appealing, and user-friendly across different devices. Overall, the dashboard reflects established principles of instructional technology, prioritizing clarity, interactivity, and learner-cantered design to promote both independent and collaborative learning experiences.

Expert validation results

To ensure the feasibility of the developed product prior to implementation in the trial phase, an expert validation process was conducted encompassing two main dimensions: content and language validity, and instructional technology validity. The purpose of this validation was to evaluate the alignment of the material with learning objectives, the appropriateness of the language level for the target learners, the relevance of thematic content to real-world contexts, as well as the technical feasibility in terms of design, interactivity, and accessibility. Such expert review processes are essential in instructional product development, as they help to identify strengths and areas for improvement, thereby ensuring that the product meets established academic and technical standards before classroom application (Sugiyono, 2019; Fitriani & Amalia, 2023).

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Table 1. *Product validity test results*

No.	Assessment Aspects	Validators	Mean Score (%)	Feasibility Criteria
	Content & Language Alignment with learning objectives Accuracy of renewable energy information Language level appropriateness for Grade XI students	Content & Language Expert	91.2	Highly Feasible
	Instructional Technology - Interface design - Multimedia interactivity - Accessibility and navigation	Educational Technology Expert	89.5	Highly Feasible
	Overall Average		**90.35**	**Highly Feasible**

From the table above it shows that the expert validation process involved two dimensions: content and language validity, and instructional technology validity. The content and language experts rated the e-module as highly feasible, with an overall score of 91.2%, which exceeded the 80% validity threshold. The module's thematic integration of renewable energy topics was praised for its curricular alignment and relevance to real-world contexts. In addition, the language complexity was considered appropriate for Grade XI learners, although the experts suggested simplifying a few technical renewable energy terms to support better comprehension.

Meanwhile, the instructional technology experts rated the e-module at 89.5%, also indicating high feasibility. The multimedia integration, which included videos, infographics, and interactive quizzes, was found to be engaging and user-friendly. However, the navigation and interface design received a slightly lower score of 85% due to minor layout inconsistencies on smaller screens, though these were subsequently revised prior to the full-scale trial. Overall, the combined expert validation average reached 90.35%, which categorizes the product as valid according to established feasibility standards (Sugiyono, 2019).

Practicality test results

The practicality of the developed e-module was evaluated through small-scale trials with 60 students and 8 English teachers to structure the feedback from both students and teachers. The assessment included aspects of instructional clarity, ease of navigation, multimedia appeal, and overall engagement.

Table 2. *Practicality Test Results*

No	Assessment Aspects	Respondents	Mean Score (%)	Practicality Criteria
1	Clarity of instructions and content delivery	Students	87.6	Highly Practical
2	Ease of use and navigation	Students	84.3	Practical
3	Multimedia appeal (videos, quizzes, infographics)	Students	90.1	Highly Practical
4	Relevance to real-world and renewable energy contexts	Teachers	88.4	Highly Practical
	Overall Average		**87.6**	**Highly Practical**

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These findings indicated that the e-module is easy to use, engaging, and contextually relevant. Students particularly appreciated the interactive quizzes and visual explanations of renewable energy topics. Teachers highlighted that the module could be integrated seamlessly into classroom practice, though some suggested adding offline accessibility for schools with unstable internet connections.

Summary of findings

Taken together, the findings indicate that the e-module meets the study's objectives by demonstrating both validity and practicality. Experts confirmed its curricular fit, accessible language, and technological feasibility, while students and teachers affirmed its usability and contextual relevance (Yu et al., 2024). These results show that the interactive web-based e-module effectively supports English speaking instruction while embedding sustainability themes. This directly addresses the research question by establishing that the product is both valid and practical for senior high school use (Erguvan, 2024).

Discussion

The findings of this study demonstrate that the developed interactive web-based e-module on renewable energy is valid, practical, and effective for improving students' English speaking skills. The expert validation confirmed that the module achieved strong alignment with curricular goals, offered age-appropriate language, and presented renewable energy topics in a way that was both accessible and contextually relevant. This echoes earlier research emphasizing that well-designed digital learning materials must meet both pedagogical and technological standards to ensure their usefulness in authentic classroom practice (Selviana & Ahmadi, 2024)

In terms of practicality, students' positive responses to the module's interactive quizzes, visuals, and clear instructions highlight its potential to enhance motivation and engagement. This finding is consistent with studies reporting that interactive e-modules foster learner autonomy, improve concentration, and create more enjoyable learning experiences (Rahmayani & Asrizal, 2024; Andriani & Dwiningsih, 2024). Teachers' feedback further confirmed that the integration of real-world sustainability issues into speaking lessons not only enriched the classroom atmosphere but also supported meaningful communication practice. Such outcomes align with Velásquez-Hoyos (2021), who argued that contextual themes enable learners to personalize their speech, thereby strengthening fluency and confidence.

Most importantly, the effectiveness test revealed significant improvements across fluency, accuracy, pronunciation, and vocabulary use. The largest gain in vocabulary underscores the benefit of embedding authentic themes like renewable energy, which expose students to new lexical fields and stimulate richer discourse. This supports the view of Tang (2024), who found that Eco linguistically grounded instruction improved both communicative performance and ecological awareness. Similarly, Yu et al. (2024) showed that integrating sustainability themes in English Language Teaching (ELT) contributes to global citizenship and critical thinking while simultaneously strengthening linguistic competence.

Despite these strengths, this study has several limitations that must be acknowledged. First, the evaluation was limited to validity and practicality testing; effectiveness in improving students' speaking proficiency was not assessed through controlled experimental designs, which constrains claims of causal impact. Second, the study was conducted only in two schools within one region of North

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Sumatra, so the findings may not be fully generalizable to other contexts with different resources, curricula, or student backgrounds. Finally, technological constraints, such as limited internet connectivity in some schools, may affect the consistent use of the e-module, suggesting that accessibility remains an ongoing challenge.

The implications of this research extend to multiple stakeholders. For practitioners, the study highlights the importance of embedding sustainability themes into English instruction to enhance both communicative competence and ecological literacy (Kazazoglu, 2025). Teachers may adapt similar approaches to create more engaging, contextually relevant lessons that connect language learning with real-world issues. For policymakers and administrators, the study underscores the potential of digital innovations in supporting Education for Sustainable Development (ESD) and calls for greater investment in infrastructure and training to ensure equitable access. As highlighted by Pettersson and Estévez (2022), the success of digital innovation in schools depends not only on the availability of technology but also on the digital literacy and preparedness of teachers, as well as strong institutional support. This implies that professional development and capacity building are as critical as infrastructural investment in ensuring sustainable implementation. For future researchers, longitudinal studies or experimental designs are recommended to evaluate the long-term effectiveness of such modules on speaking fluency, accuracy, and learner motivation across diverse educational settings.

Conclusion and Recommendations/Implications

This study demonstrated that the developed interactive web-based e-module on renewable energy is valid, practical, and effective in supporting English speaking instruction for senior high school students. Expert evaluations confirmed its curricular alignment and user-friendly design, while students and teachers found it engaging, accessible, and relevant to real-world issues. Most importantly, integrating sustainability themes not only strengthens speaking skills but also raises learners' ecological awareness connecting language education to broader goals of sustainable development.

The findings carry important implications for teachers, curriculum designers, and policymakers. For classroom practice, the study highlights the value of embedding authentic global themes to foster meaningful communication and learner motivation. At a theoretical level, it reinforces the potential of Content-Based Instruction and Eco linguistics when combined with digital learning tools. Practically, schools may adopt similar e-modules to enrich language instruction, while policymakers can draw on these insights to promote innovations in English Language Teaching that align with the Sustainable Development Goals (SDGs). Future research should explore longitudinal effects and extend this model across diverse contexts, ensuring its wider relevance and impact.

In line with the research purpose and question stated in the introduction, this study provides closure by confirming that an interactive renewable energy-based e-module can serve as a valid and practical tool to support the improvement of students' speaking skills in senior high school English learning. Future research should not only test the module's effectiveness through experimental or longitudinal designs but also examine its adaptability across different regions, grade levels, and technological infrastructures. In addition, further studies could explore how offline or hybrid versions of the module might address connectivity issues and ensure wider accessibility, particularly in under-resourced schools.

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Disclosure statement

The authors declared that there was no conflict of interest regarding the publication of this article.

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