

Development and Initial Validation of a Web-Based Interactive Bilingual Module for MKDU Learning in Higher Education

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Abstract

Digital transformation in higher education requires adaptive, flexible, and relevant instructional materials that respond to the characteristics of digital-native students. General Basic Courses, locally referred to as Mata Kuliah Dasar Umum (MKDU), play a strategic role in developing interdisciplinary competencies; however, their instructional delivery remains largely conventional and has not been optimally integrated with digital technology and bilingual academic literacy support. This study aims to develop and conduct an initial validation of a web-based interactive bilingual module to support MKDU learning in higher education. This study employed a Research and Development (R&D) approach by adapting the Borg and Gall model, including needs analysis, product planning, initial prototype development, expert validation, product revision, and limited user testing. Data were collected through questionnaires administered to 30 students, semi-structured interviews with three MKDU lecturers, expert validation, and user response questionnaires involving 15 students. The needs analysis showed that 83.3% of students required web-based learning access, 86.7% needed bilingual presentation, and 90.0% preferred interactive quizzes and multimedia features. Expert validation indicated that the prototype was valid to highly valid, with Aiken's V scores ranging from 0.88 to 0.91, while user responses showed good to very good ratings. The main contribution of this study is the development of an initial web-based bilingual MKDU module prototype that integrates user needs analysis, TPACK principles, bilingual academic terminology, multimedia, and formative quizzes within a unified digital learning environment.

Keywords: Bilingual Module; Web-Based Learning; MKDU; TPACK; Higher Education

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INTRODUCTION

The development of information technology has significantly transformed the implementation of learning in higher education. The integration of technology into the learning process is no longer viewed as a supplementary element, but as a necessity to address demands for flexibility, accessibility, and the characteristics of digital-native students. Web-based learning enables instructional materials to be accessed beyond the limitations of time and place while also facilitating broader interaction between lecturers and students. Digital transformation has also changed the development of instructional materials, shifting from printed or static presentation-based materials to open, interactive, and widely distributed digital learning resources. Open course and online course models expand students' access to global academic content and provide opportunities for non-Anglophone students to develop English academic literacy through online participation, digital discussion, and exposure to cross-border learning materials (Morgan & Carey, 2009; Carey, 2010). Therefore, the digitalization of instructional materials is not only related to the provision of platforms, but also to the expansion of

access, cross-institutional collaboration, and the strengthening of students' academic literacy (Alenezi & Akour, 2023; Yanna et al., 2024). In addition, the use of digital technology has the potential to support more autonomous and student-centered learning when designed systematically and aligned with learning objectives (Zhang et al., 2020; Bond et al., 2020).

General Basic Courses, locally referred to as Mata Kuliah Dasar Umum (MKDU), have a strategic position in higher education curricula because they contribute to the development of basic competencies, academic character, and critical thinking skills across disciplines. However, the learning process in MKDU is still frequently dominated by conventional approaches that have not fully utilized the potential of digital technology as a learning support system. At the same time, the increasing demand for English academic literacy requires learning resources that can introduce global academic terminology without reducing students' understanding of core concepts. This need is particularly relevant for students in non-language programs, including engineering students, because academic literacy demands are not limited to general English proficiency but also include the ability to understand disciplinary terminology, academic genres, and scientific communication practices (Murray, 2010; Lum et al., 2018). In this context, MKDU instructional materials need to help students understand basic concepts while also recognizing English academic terms commonly used in international literature and professional communication.

Previous studies have shown that web-based learning has the potential to improve students' learning experiences when supported by interactive and well-planned instructional design. Bond et al. (2020), through a systematic evidence map, reported that student engagement in digital learning is strongly influenced by the quality of learning activity design and the meaningful use of technology. Similarly, Nguyen (2021) concluded that the effectiveness of web-based learning in higher education depends on how technology is integrated with appropriate pedagogical strategies, not merely on the use of digital platforms. In the Indonesian context, Suryani (2021) and Pratama and Lestari (2022) also showed that web-based learning can support students' independent learning when developed systematically and contextually. However, research on web-based learning media for general courses still needs to be strengthened, particularly in terms of integrating academic literacy into content-based learning. Wingate (2022) emphasized that academic literacy development should not be treated merely as separate language support, but should be embedded in content teaching through explicit pedagogical design.

On the other hand, studies on bilingual learning indicate that the use of two languages in presenting learning materials can help students understand concepts while strengthening their mastery of academic terminology. Richards and Rodgers (2014) emphasized that contextual exposure to the target language is an important strategy for supporting the learning process. In line with this view, Tseng and Yeh (2021) showed that bilingual approaches in higher education can function as linguistic scaffolding that helps students connect conceptual understanding with the use of English academic terms. Translingual and multilingual perspectives in higher education also emphasize that students' languages should not be seen as barriers, but as learning resources that can strengthen content understanding. Page (2023) highlighted the importance of translingual practices in reducing linguistic discrimination and accommodating students' diverse linguistic repertoires, while Tkachenko et al. (2016) stressed the need for dialogic and intercultural approaches to support multilingual students. Thus, bilingual presentation in an MKDU module should not be understood merely as the translation of terms, but as a pedagogical strategy that connects language, content, and academic literacy.

Nevertheless, previous studies have generally developed web-based learning media and bilingual materials separately. Studies on web-based learning tend to focus on technology implementation and its impact on learning processes, while studies on bilingual learning often emphasize linguistic aspects or language learning. In addition, most studies have developed products for specific subjects or fields, such as language, science, and vocational education, and have paid limited attention to MKDU learning needs in engineering study programs. Another research gap lies in the limited availability of web-based media designs that simultaneously integrate general course content, English academic literacy support, interactive features, and user needs analysis. Literature on English Medium Instruction and English for Specific Purposes suggests that students in non-language programs require literacy support embedded in content learning, rather than separate general English courses (Baştürkmen, 2012; Wingate, 2022; Chen et al., 2023).

Based on these conditions, there remains a research gap in the development of an MKDU module model that simultaneously integrates bilingual approaches as academic scaffolding, web-based interactivity, user needs analysis, and the Technological Pedagogical Content Knowledge (TPACK) framework in the context of engineering students. Engineering students, who require flexible learning and global academic literacy, need instructional materials that do not merely use technology but also consider pedagogy, content, and user needs in an integrated manner.

The development of the module in this study is based on the principle that the use of technology must be supported by a strong pedagogical foundation. Mayer (2014) explained that the integration of text and visual elements, when designed appropriately, can enhance students' conceptual understanding through the principles of multimedia learning. In addition, the TPACK framework introduced by Koehler and Mishra (2009) emphasizes that effective technology integration must consider the balance among technology, pedagogy, and content so that learning can be supported meaningfully. In this study, TPACK serves as the basis for designing a module that not only presents materials digitally but also integrates pedagogical strategies through bilingual presentation, multimedia, systematic navigation, and formative quizzes. This integration is important because effective online learning requires design that supports flexibility, student engagement, feedback, and independent learning.

Based on the background and research gap described above, this study aims to identify students' and lecturers' needs for the development of a web-based bilingual module, design an interactive module prototype for MKDU learning in engineering study programs, and conduct an initial validation of the developed prototype. Specifically, this study addresses three research questions: (1) What are students' and lecturers' needs for a web-based interactive bilingual module for MKDU learning? (2) How can a module prototype be designed in accordance with user needs and TPACK principles? and (3) What is the initial feasibility of the prototype based on expert validation and limited user responses? Therefore, the main contribution of this study lies in the development of a module design and prototype based on user needs analysis and grounded in TPACK principles and a bilingual approach. This study is not intended to experimentally test learning effectiveness, but to provide a conceptual basis, product design, initial validation, and user responses as a foundation for further development and evaluation.

METHOD

Research Design

This study employed a Research and Development (R&D) approach by adapting the Borg and Gall (2003) development model. The Borg and Gall model was selected because it provides a systematic framework for developing, validating, revising, and refining

educational products based on user needs and expert feedback. In educational research, this model is often adapted into fewer stages according to context, resources, and research objectives, while maintaining the core process of needs analysis, planning, initial product development, validation, revision, and limited testing (Rabiah, 2018; Prasetyo et al., 2022; Farih & Dewi, 2021; Azami & Rahmawati, 2023; Nurlaela et al., 2023).

In accordance with the objectives of this study, the development process was conducted through five main stages: (1) needs analysis, (2) product planning, (3) initial prototype development, (4) expert validation and product revision, and (5) limited user testing. These stages were selected because this study focused on developing and examining the initial feasibility of the prototype, rather than testing product effectiveness through an experimental design. Therefore, this study produced a web-based interactive bilingual module prototype that had received expert feedback and initial user responses, but had not yet tested its impact on students' learning outcomes empirically.

Participants and Research Context

The study was conducted in Electrical Engineering and Informatics study programs that offered MKDU courses during one academic semester. The participants consisted of 30 students selected using purposive sampling. The selected students were those who were taking MKDU courses and had experience using digital learning platforms. In addition to students, the study involved three MKDU lecturers as informants during the needs analysis stage. Their involvement aimed to obtain information about learning characteristics, challenges faced during the teaching process, and the need for web-based learning media and bilingual approaches. During the validation stage, the prototype was reviewed by expert validators with competence in MKDU content, instructional media design, and bilingual readability. During the limited testing stage, the prototype was provided to 15 students to obtain initial responses regarding ease of use, clarity of materials, interface display, quality of interactive quizzes, and overall satisfaction.

Needs Analysis Procedure

The needs analysis stage was conducted to identify students' and lecturers' needs for the development of a web-based interactive bilingual module for MKDU learning. Student data were collected through questionnaires using a five-point Likert scale designed to measure three main aspects: (1) the need for flexible web-based learning access, (2) the need for the integration of bilingual academic terminology in learning materials, and (3) preferences for interactive features such as quizzes and multimedia. Lecturer data were obtained through semi-structured interviews focusing on experiences in teaching MKDU, learning challenges, the need for instructional media innovation, and views on the use of technology and bilingual approaches to support the learning process. The interviews were used to deepen the quantitative data obtained from the questionnaires so that user needs could be understood more comprehensively from both student and lecturer perspectives.

Prototype Design and Development

The results of the needs analysis were used as the basis for developing the blueprint of the web-based bilingual module. This stage included mapping learning outcomes, organizing material structures, designing navigation, and developing learning activity designs.

The prototype was developed by integrating bilingual material presentation, interactive exercises and quizzes, and multimedia elements into a web-based learning environment. The bilingual presentation was designed by presenting core concepts in Indonesian enriched with English academic terminology as a form of support for

students' academic literacy. In addition, the navigation structure was systematically designed to help students access materials and learn independently.

The prototype development referred to the TPACK framework, which emphasizes the integration of technology, pedagogy, and content knowledge (Koehler & Mishra, 2009). The technological aspect was realized through the use of a web-based platform, responsive navigation, multimedia, and interactive quizzes. The pedagogical aspect was reflected in the gradual learning flow, formative feedback, and support for independent learning. The content aspect was represented through the presentation of MKDU materials and bilingual academic terminology relevant to the needs of engineering students.

Research Instruments and Data Collection

The research instruments consisted of a needs analysis questionnaire, semi-structured interview guide, expert validation sheet, and user response questionnaire. The needs analysis questionnaire was used to obtain quantitative data regarding students' needs and preferences for module development. The interviews were used to obtain qualitative data regarding lecturers' perspectives on MKDU learning needs.

The expert validation sheet was used to assess the feasibility of the prototype in terms of material relevance, conceptual accuracy, bilingual readability, navigation, and interactivity. The user response questionnaire was used to determine students' initial acceptance of the prototype, particularly in terms of ease of use, clarity of materials, interface display, quality of interactive quizzes, and overall satisfaction.

Before use, the instruments were developed based on the research objectives and indicators derived from the literature on web-based learning, bilingual learning, academic literacy, and instructional media development. The instruments were then reviewed by peers and academic supervisors to ensure clarity of wording and alignment between indicators and research objectives. The internal consistency of the user response questionnaire was analyzed using Cronbach's Alpha. An alpha value of 0.70 or higher is generally considered acceptable, while higher values indicate stronger internal consistency (Cronbach, 1951; Weisdiyanti et al., 2023).

Expert Validation and Limited User Testing

Expert validation was conducted to obtain an initial assessment of the feasibility of the prototype before limited user testing. Each validator assessed the aspects of material relevance, conceptual accuracy, bilingual readability, navigation, and interactivity using a prepared rating scale. The validation data were analyzed using Aiken's V index to determine the level of expert agreement on the feasibility of each aspect. Aiken's V values closer to 1 indicate a high level of content validity (Aiken, 1985).

After expert validation, the prototype was revised based on validators' comments and suggestions. The revisions included improving concept definitions, simplifying bilingual terms, adding references to materials, and strengthening feedback in formative quizzes. The revised prototype was then tested on a limited basis with 15 students to obtain initial user responses. This limited testing was not intended to measure learning effectiveness, but to assess usability, readability, interface comfort, and students' initial acceptance of the module.

Data Analysis

Quantitative data from the questionnaire were analyzed using descriptive statistics, including frequency, percentage, mean, and standard deviation, to describe students' needs for the development of a web-based interactive bilingual module. Expert validation data were analyzed using Aiken's V, while user response data were analyzed using mean

scores and categorical interpretation. The reliability of the user response instrument was analyzed using Cronbach's Alpha. Qualitative data from the interviews were analyzed using thematic analysis. The analysis was conducted through several stages: repeatedly reading the transcripts, conducting initial coding, grouping codes into themes, reviewing theme consistency, naming the themes, and presenting the themes with relevant excerpts or summaries. This procedure was used to identify patterns in lecturers' needs related to learning access, bilingual terminology support, and interactive material design (Braun & Clarke, 2006; Sunzuma & Umbara, 2025). The quantitative and qualitative findings were then used as the basis for designing and revising the module prototype.

RESULTS AND DISCUSSION

Student Needs Analysis

The initial stage of the study focused on student needs analysis as the basis for designing the web-based bilingual module prototype. The analysis was conducted by distributing questionnaires to 30 students to obtain an overview of learning preferences, needs for digital media, and expectations for features that support the learning process. The results showed that most respondents preferred a learning system that could be accessed flexibly through the web, presented in a bilingual format, and equipped with multimedia and interactive quizzes.

These findings indicate that students need not only access to learning materials anytime and anywhere, but also a more engaging and communicative learning experience that helps them understand English academic terms. Bilingual presentation was viewed as helping students transition between concepts in Indonesian and international terms commonly used in academic references. Meanwhile, interactive quizzes provided opportunities for students to receive immediate feedback on their level of understanding during independent learning. Therefore, needs analysis serves as an important foundation for designing learning media that align with user characteristics and developments in educational technology.

Table 1. Results of Student Needs Analysis (n = 30)

Indicator	Frequency	Percentage	Mean (Likert 1-5)	SD	Interpretation
Need for web-based learning access	25	83.3%	4.15	0.58	High
Need for bilingual presentation	26	86.7%	4.32	0.51	Very high
Need for interactive quizzes and multimedia	27	90.0%	4.48	0.46	Very high

Based on Table 1, the need for interactive quizzes and multimedia obtained the highest percentage at 90.0%, followed by the need for bilingual presentation at 86.7% and web-based learning access at 83.3%. All indicators had mean scores above 4.00, indicating a high level of need for these features. These results suggest that students expect learning media that are not only easily accessible but also capable of providing active learning experiences through multimedia integration, formative evaluation, and the use of two languages. These findings became the basis for determining development priorities, especially in terms of accessibility, interactivity, and bilingual academic terminology presentation

MKDU Lecturers' Perspectives

The results of interviews with MKDU lecturers were analyzed using a thematic approach and produced three main themes: the need for flexible learning access, the importance of bilingual academic terminology support, and the need for interactive and visually oriented materials. These themes show that lecturers view digital technology as a means of extending learning beyond the classroom while providing students with opportunities to learn independently.

The bilingual approach was considered useful in helping students understand English academic terms frequently encountered in international literature without reducing their understanding of the main concepts. In addition, lecturers stated that materials combining text, images, videos, and interactive activities could increase students' attention and support a more effective learning process.

Table 2. Summary of Lecturer Interview Themes

Theme	Description
Theme 1: Need for flexible learning access	Media are needed that can be accessed outside face-to-face class hours.
Theme 2: Need for bilingual academic terminology support	English academic terms need to be introduced gradually.
Theme 3: Need for interactive and visually oriented materials	Students are more interested in visual materials and interactive activities.

One lecturer stated, "Students need visual and practical materials that can be accessed anytime to reinforce classroom learning." This statement strengthens the student needs analysis results, which showed a high interest in flexible and interactive digital learning media. The alignment between student needs and lecturer perspectives indicates that the development of a web-based module with a bilingual approach is relevant to supporting MKDU learning. The synergy between user needs and lecturer perspectives provides a strong conceptual basis for designing learning media that respond to challenges in higher education learning.

Prototype Design

Based on the needs analysis and interview results, a web-based bilingual module prototype was developed with systematic and responsive navigation so that it could be accessed through both computers and smartphones. The module was designed to support independent learning through organized material presentation, bilingual academic terminology, multimedia integration, and formative quizzes. The menu structure consisted of Home, MKDU List, Learning Materials, Bilingual Academic Terms, Supporting Multimedia, Formative Quizzes, Summary, and References. This menu structure was designed to provide a clear learning flow so that students could study materials gradually from concept introduction to comprehension evaluation.

Module Menu Structure

1. Home
2. MKDU List
3. Learning Materials
4. Bilingual Academic Terms
5. Supporting Multimedia
6. Formative Quizzes
7. Summary
8. References

Table 3. Example of Bilingual Presentation

Indonesian	English
Integritas Akademik	Academic Integrity
Hak dan Kewajiban Warga Negara	Rights and Responsibilities of Citizens
Berpikir Kritis	Critical Thinking

Example of Quiz

Question: *Academic integrity refers to ...*

- Sharing answers during examinations
- Acting honestly in academic activities
- Ignoring citation rules
- Copying assignments from others

Correct answer: b.

In addition to text-based materials, the module was equipped with images, icons, short videos, and infographics to increase visual appeal and facilitate conceptual understanding. Bilingual terms were presented side by side so that students could recognize English academic equivalents contextually. Formative quizzes were designed to provide immediate feedback, allowing users to evaluate their understanding after studying specific materials. The integration of these components reflects an effort to combine technology, learning strategies, and content presentation in one platform that supports a more effective and flexible learning experience.

Expert Validation

The validation stage was conducted to assess the quality of the prototype in terms of material relevance, conceptual accuracy, bilingual readability, navigation, and interactivity. The results showed that all aspects were categorized as valid to highly valid, with Aiken's V values ranging from 0.88 to 0.91. Material relevance obtained the highest score, while bilingual readability received suggestions for simplifying several terms to make them easier to understand. Validators also recommended adding references to materials, improving concept definitions, and strengthening quiz feedback so that product quality could be further improved before implementation.

Table 4. Expert Validation Results

Aspect	Score	Aiken's V	Category	Notes
Material relevance	4.7	0.91	Highly valid	Add references
Conceptual accuracy	4.6	0.89	Highly valid	Improve definitions
Bilingual readability	4.5	0.88	Valid	Simplify terms

The assessment instrument also showed good reliability, with a Cronbach's Alpha value of 0.89, indicating adequate internal consistency among items. Overall, the validation results indicate that the prototype met feasibility criteria in terms of content and design. However, several suggestions from validators were used as the basis for improving the product before further implementation and evaluation with users.

Limited User Testing

Limited user testing was conducted with 15 students to obtain an initial overview of user acceptance of the developed prototype. The evaluation covered ease of use, clarity of materials, interface display, quality of interactive quizzes, and overall satisfaction. The results showed that all aspects received good to very good ratings, with mean scores above 4.00. Students responded positively to the systematic presentation of materials, the use of bilingual terms that helped them understand academic vocabulary, and the presence of interactive quizzes that provided immediate feedback. In addition, the

responsive interface design facilitated access through various devices, thereby supporting learning flexibility.

Table 5. User Responses

Aspect	Mean	Interpretation
Ease of use	4.40	Very good
Clarity of materials	4.32	Good
Interface display	4.51	Very good
Interactive quizzes	4.47	Very good
Overall satisfaction	4.43	Very good

Results show that students' needs and lecturers' perspectives were aligned in emphasizing the importance of flexible, interactive learning media that support bilingual academic terminology. The developed prototype sought to respond to these needs through the integration of digital materials, multimedia, and formative evaluation in a web-based platform. These findings are also consistent with the TPACK framework, which emphasizes the integration of technology, pedagogy, and content in creating effective learning experiences. Thus, the developed web-based bilingual module has the potential to support independent learning, increase student engagement, and facilitate a more comprehensive understanding of both content and academic terminology.

The developed module prototype was designed as a web-based learning medium with a hierarchical navigation structure that allows students to access materials systematically through various devices. Based on the needs analysis, the module design integrates materials in Indonesian with English academic terminology, enabling students to understand core concepts while expanding their academic vocabulary relevant to international literature. This bilingual approach was applied consistently across subtopics and supported by visual elements, responsive layout, and multimedia to improve readability and user comfort.

The findings of this study indicate that the development of digital instructional materials for MKDU should be understood as an instructional design process that combines access, content, language, and interactivity. The high percentages of students' needs for web-based access, bilingual presentation, and quizzes and multimedia indicate that students require not only flexible access to materials, but also support for understanding academic terms and evaluating their own understanding. This is consistent with online learning studies emphasizing that the flexibility of web-based learning can support self-directed learning when accompanied by clear design, feedback, and technological support (Muir et al., 2022; Nhan, 2024; Joshi, 2024).

Furthermore, the module covers three MKDU areas: English, Religious Education, and Civic Education. Therefore, its development is not limited to one subject area but is designed as a cross-disciplinary learning environment that supports broader academic literacy development. This structure indicates that the product accommodates users' needs for flexible learning access, understandable material presentation, and technology integration that supports the learning process. Thus, the module design does not merely focus on the digitalization of materials but seeks to build a more structured, adaptive, and relevant learning experience for students in higher education.

The results of this study strengthen the argument that web-based learning can support students' learning flexibility. Students' need for web access indicates that they require learning resources that can be used outside the classroom, according to their own time and learning pace. In higher education, this flexibility is important because students have varying academic readiness, language proficiency, and experience in using technology. Muir et al. (2022) emphasized that online learning environments can expand access and support independent learning regulation when equipped with learning structures, feedback, and adequate interactive activities.

However, flexibility does not automatically produce effective independent learning. Nhan (2024) showed that online learning may also present challenges such as digital literacy gaps, limited self-regulation, and low social presence if the learning design does not provide sufficient support. Therefore, the module design in this study places systematic navigation, material summaries, formative quizzes, and multimedia as important components to help students regulate their learning process. Thus, web-based learning in this study does not merely function as a medium for distributing materials, but as a learning environment designed to support student autonomy and engagement.

Students' need for bilingual presentation indicates that students in non-language programs still require English academic literacy support in understanding MKDU materials. This finding is consistent with the view that academic literacy cannot be reduced to general English proficiency, because each field has its own terminology, genres, and academic communication practices (Murray, 2010; Lum et al., 2018). In the context of engineering students, the introduction of English academic terminology through MKDU modules can help students adapt to international literature and cross-disciplinary academic communication.

The bilingual approach in this study is closely related to the principles of Content and Language Integrated Learning (CLIL), which integrates content and language learning within one instructional design. Previous studies have shown that bilingual or CLIL approaches can support the mastery of academic terms and disciplinary competencies when accompanied by terminology support, glossaries, clear definitions, and appropriate usage contexts (Khomenko et al., 2023; Sytniakivska & Lityaga, 2020; Yao et al., 2024). Wang et al. (2025), for example, showed that the use of bilingual materials and terminology explanations in medical education can support students' academic and clinical competencies.

Nevertheless, bilingual learning should not be understood as a mechanical process of translating terms. Hu (2008) warned that a bilingual approach focused only on vocabulary translation does not always lead to better conceptual understanding. Lin and He (2018, 2019) also showed that bilingual learning outcomes may vary depending on students' language readiness, the quality of learning support, and the suitability of instructional design. Therefore, the bilingual presentation in this module is designed as academic scaffolding, namely gradual support that helps students understand concepts in Indonesian while recognizing English academic terms contextually.

Interactive features became one of the main components of the prototype design through the provision of short quizzes at the end of each subtopic as a form of formative evaluation. Each learning session included English-based questions designed to provide immediate feedback on students' understanding of the material they had just studied. Although the number of questions was relatively limited, this approach is aligned with microlearning principles, which emphasize short but focused learning activities to maintain attention and increase learner engagement.

Formative quizzes play an important role in supporting self-regulated learning because they help students monitor understanding, identify materials that have not yet been mastered, and adjust learning strategies. In online learning environments, quick and structured feedback can increase engagement, motivation, and students' ability to manage their own learning process (Muir et al., 2022). Therefore, quizzes in this module are not positioned merely as final evaluation tools, but as part of the learning process that provides opportunities for students to reflect and improve independently.

The integration of English-based quizzes also supports the bilingual purpose of the module because students not only read academic terms but also use them in question contexts. Thus, the quiz feature connects three main aspects of the module design: content mastery, English academic literacy, and self-regulation. This finding is consistent

with literature emphasizing that effective online learning needs to combine content goals, language support, and feedback mechanisms so that students not only access materials but also monitor their learning progress (Al-Ahdal & Aljabr, 2023; Muir et al., 2022; Nhan, 2024).

The presence of visual illustrations, supporting multimedia, and responsive layout strengthens the learning experience by providing varied information presentation according to user preferences. The limited testing results, which showed positive responses to ease of use, interface display, and interactive quizzes, indicate that the design met users' initial needs. Therefore, the combination of bilingual presentation, multimedia, and formative evaluation is an important characteristic that distinguishes this module as a web-based learning medium oriented toward student engagement.

This finding supports multimedia learning principles, which state that the combination of text, images, videos, and visualizations can help students build conceptual understanding when designed purposefully and without overloading cognition (Mayer, 2014; Clark & Mayer, 2016). In online learning contexts, multimedia also functions to increase students' attention and engagement. Muir et al. (2022) showed that online materials equipped with multimedia, interaction, and feedback can strengthen the relationship among students, content, and instructors. Joshi (2024) and Nhan (2024) also emphasized that user-friendly interface design and accessible multimedia content play important roles in increasing user acceptance of online learning platforms.

However, multimedia use still requires pedagogical consideration. Excessive or irrelevant multimedia may distract students' attention. Therefore, multimedia in this module needs to be positioned as support for conceptual understanding, not merely as decorative elements. This principle is consistent with the TPACK framework, because the selection of technology should always be aligned with pedagogical objectives and content characteristics.

The findings of this study show that students' needs and lecturers' perspectives both point to the importance of learning media that are flexible, accessible, and capable of supporting academic literacy through a bilingual approach. This condition became the basis for designing a web-based module that integrates material delivery, English academic terminology, multimedia, and interactive quizzes in one learning platform.

Compared with previous studies on module or bilingual multimedia development that generally focused on language or science subjects, this study contributes to the context of MKDU in engineering study programs, where students do not come from language disciplines but still need to understand international academic terminology. The findings are also consistent with national studies emphasizing the importance of developing learning media based on students' needs in Indonesian higher education contexts (Suryani, 2021; Rahmawati, 2020). In addition, Tseng and Yeh (2021) showed that bilingual approaches in higher education can support conceptual understanding without reducing the clarity of the main content.

The main contribution of this study lies in the integration of three components that have often been studied separately: web-based learning, bilingual support for academic literacy, and interactive design based on formative evaluation. This study also extends the application of bilingual approaches from language learning contexts to MKDU learning for engineering students. Therefore, this study responds to the need identified in the literature for digital instructional materials that not only deliver content but also integrate academic literacy support into general or disciplinary learning (Wingate, 2022; Page, 2023; Chen et al., 2023).

From a theoretical perspective, these findings are consistent with the Technological Pedagogical Content Knowledge framework proposed by Koehler and Mishra (2009), which emphasizes that the effectiveness of technology use depends on the balance among

technology, pedagogy, and learning content. Furthermore, Bond et al. (2020) explained that successful technology integration in higher education is strongly influenced by instructional design quality and students' active participation in the learning process. In this context, the developed module does not merely use technology as a medium for distributing materials but also integrates pedagogical strategies through formative evaluation and bilingual content presentation that support independent learning.

Practically, the results of this study imply that MKDU lecturers can develop digital instructional materials by considering four main principles. First, materials should be organized in an easy-to-navigate web structure to support learning flexibility. Second, bilingual presentation should focus on strengthening academic terminology, not merely translating words. Third, formative quizzes should be accompanied by feedback so that students can monitor their understanding independently. Fourth, multimedia should be used selectively to clarify concepts and increase learning engagement.

Although the study shows positive results at the initial development stage, several limitations need to be considered when interpreting the findings. First, the module development was still at the initial validation and limited testing stage. Therefore, the evaluation focused on needs analysis, product feasibility, and initial user responses, rather than measuring effectiveness in improving students' learning outcomes through an experimental design. As a result, this study has not yet provided empirical evidence regarding the effect of the module on academic achievement, competency improvement, or changes in students' literacy skills quantitatively.

Second, the number of respondents involved in the needs analysis and limited testing was restricted to one study program in one higher education institution. Therefore, the user characteristics obtained may not fully represent conditions in other universities or different academic fields. Third, the product evaluation focused more on feasibility, acceptance, and design quality than on the long-term impact of module use on students' learning behavior.

CONCLUSION

This study shows that students have a high level of need for the development of a web-based interactive bilingual module as a supporting medium for MKDU learning. The needs analysis indicated that 83.3% of students required web-based learning access, 86.7% needed bilingual presentation to help them understand academic terminology, and 90.0% expected interactive features such as quizzes and multimedia. These findings suggest that flexible access, academic literacy support, and interactive learning activities are important aspects that need to be considered in developing learning media for engineering students.

Based on these needs, this study produced a web-based bilingual module prototype that integrates English, Religious Education, and Civic Education materials within one digital learning environment. The prototype includes systematic navigation, bilingual terminology presentation, multimedia support, and formative quizzes. Expert validation results showed that the prototype was categorized as valid to highly valid, while limited user testing indicated positive responses from students regarding ease of use, interface display, interactive quizzes, and overall satisfaction.

The contribution of this study lies in the development of an initial web-based bilingual module model designed based on user needs analysis and integrating technology, pedagogy, and content according to the TPACK framework. Unlike previous studies that generally developed web-based media or bilingual materials separately, this study combines both approaches in the context of MKDU learning for engineering students and covers several general course areas in an integrated manner. Therefore, the

developed module can serve as an alternative learning medium that is more flexible, structured, and supportive of independent learning in the digital era.

RECOMMENDATIONS

Drawing on the findings and limitations of this study, several recommendations are proposed for future work. First, the effectiveness of the web-based bilingual module should be tested through experimental or quasi-experimental research designs. This is necessary to provide stronger evidence of its impact on students' learning achievement, academic literacy, engagement, and self-regulated learning. Second, future development and validation should involve a wider and more heterogeneous group of participants from various study programs and higher education institutions. Broader participation would help determine whether the module is relevant and applicable across different academic learning contexts. Third, the bilingual academic literacy component should be further improved by incorporating a richer glossary, more contextual examples, bilingual practice activities, and terminology-focused tasks. These additions are important so that bilingual content serves as meaningful academic support, rather than functioning only as direct translation. Fourth, the module's interactive features should be enhanced through adaptive quizzes, instant explanatory feedback, progress monitoring, and reflective learning tasks. Such features may support students in evaluating their understanding and developing more independent learning habits. Finally, future implementation should take into account students' English proficiency, digital literacy, and internet accessibility to ensure inclusive, practical, and effective use.

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