

## Development of an Interactive E-Module for Wired and Wireless Network Technology Learning at SMK Negeri 1 Sijunjung

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### ABSTRACT

This study aimed to develop an interactive electronic module (e-module) for the Wired and Wireless Network Technology subject at SMK Negeri 1 Sijunjung and to evaluate its validity and practicality as a digital learning medium in vocational education. The research employed a Research and Development (R&D) approach using the ADDIE model, which consists of analysis, design, development, implementation, and evaluation stages. The participants involved media experts, subject-matter experts, teachers, and Grade XI students of the Computer and Network Engineering program. Data were collected through observations, interviews, validation questionnaires, practicality questionnaires, and student response questionnaires. The collected data were analyzed using descriptive quantitative techniques. The developed e-module was created using Adobe Animate in HTML5 format and integrated multimedia components such as text, images, videos, audio, animations, and interactive exercises. The validation results showed that the e-module obtained a score of 84.03% from media experts and 93.30% from subject-matter experts, indicating that the module was categorized as very valid. The practicality test results showed scores of 93.75% from teachers and 88.52% from students, which were classified as very practical. In addition, student responses indicated that the e-module supported learning engagement, independent learning, and understanding of networking concepts more effectively. These findings indicate that the developed e-module is feasible and practical for use as a digital learning medium in vocational education and can support more flexible and interactive learning activities.

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## 1. INTRODUCTION

The rapid advancement of information and communication technology has significantly influenced educational practices, especially in the development of digital learning media. In today's learning environment, educational institutions are increasingly encouraged to implement innovative and technology-based instructional materials to improve students' learning outcomes and engagement. Digital learning systems are considered capable of supporting flexible, student-centered, and independent learning processes [1].

In vocational education, learning activities are not only focused on theoretical understanding but also on developing practical competencies that are relevant to workplace demands. Therefore, the availability of appropriate learning media becomes an important aspect of the learning process. Several previous studies reported that interactive e-modules integrating multimedia components such as text, images, animation, video, and audio can improve students' understanding, motivation, and learning independence [2].

The use of multimedia in learning is closely related to Multimedia Learning Theory proposed by Mayer, which explains that students learn more effectively when verbal and visual information are presented together in an integrated form [3]. However, the presentation of excessive information may also increase students' cognitive burden. Cognitive Load Theory states that instructional materials should be designed carefully to avoid cognitive overload that may reduce learning effectiveness [4]. Therefore, the design of interactive learning media should consider not only visual attractiveness but also the organization and clarity of information delivery.

In addition, constructivist learning theory explains that learning occurs when students actively build knowledge through experience and interaction with learning materials. Interactive e-modules provide opportunities for students to explore concepts independently, solve problems, and relate learning content to practical situations encountered in vocational learning activities. This approach is considered suitable for vocational education because it supports the development of both conceptual understanding and technical skills [5].

Another supporting theory is Self-Directed Learning Theory, which emphasizes learners' ability to manage and direct their own learning activities. Through interactive e-modules, students can access learning materials flexibly, repeat lessons independently, and adjust their learning pace according to their individual abilities [6],[7]. This flexibility is important in vocational education, where students often require repeated practice and independent learning experiences to strengthen competencies.

Furthermore, the Technology Acceptance Model (TAM) explains that the successful implementation of educational technology is influenced by users' perceptions regarding usefulness and ease of use. Learning media that are easy to operate and beneficial for learning activities tend to increase students' motivation, participation, and acceptance of technology-based learning systems [8].

Despite these advantages, several challenges are still found in vocational high schools. Based on preliminary observations, the learning process is still dominated by conventional teaching methods, while the use of interactive learning media remains limited. As a result, students' participation and independent learning motivation are relatively low. Previous studies have discussed e-module development; however, many of them have not specifically focused on vocational learning characteristics and the integration of instructional design principles [9], [10].

Therefore, this study develops an interactive e-module based on the ADDIE model [11], which provides a systematic framework for instructional media development [12]. The novelty of this research lies in the integration of multimedia learning principles, cognitive load considerations, and vocational learning characteristics into an ADDIE-based interactive e-module for vocational network technology learning.

## 2. RESEARCH METHOD

This study employed a Research and Development (R&D) approach using the ADDIE instructional design model proposed by Branch [13]. The ADDIE model consists of five stages: analysis, design, development, implementation, and evaluation, which provide a structured framework for developing educational media. This approach is widely used in instructional media research because it supports iterative product validation and revision processes.

Data were collected through observations, interviews, validation questionnaires, and practicality questionnaires. A Likert scale was applied to evaluate the validity and practicality of the developed e-module following established educational research methods [14]. Quantitative data were analyzed descriptively using percentage calculations, while qualitative data obtained from observations and interviews were used to support data interpretation through triangulation techniques [15].

The implementation of the ADDIE model in this study facilitated the identification of learning needs, the design of multimedia-based instructional materials, product development, classroom implementation, and evaluation of the e-module's feasibility and practicality. Through this approach, the developed e-module was expected to support effective and flexible learning processes in vocational education.

### 2.1 Research Procedure

The research was conducted sequentially following the ADDIE model, which consists of analysis, design, development, implementation, and evaluation stages [16]. During the Analysis phase, observations and interviews were carried out with subject teachers and Grade XI students to identify learning challenges and instructional requirements. This phase also involved examining learning outcomes and learning objectives in accordance with the Merdeka Curriculum to ensure content relevance.

In the Design phase, a storyboard and interface layout for the electronic module were developed. The module structure included the cover page, user guidelines, learning materials, exercises, assessments, and references. Principles of user-friendliness and interactive learning were incorporated to enhance accessibility and learner engagement. During the Development phase, the electronic module was created using Adobe Animate in HTML5 format by integrating multimedia components such as text, images, videos, audio, and animations [17]. The product was subsequently validated by media experts and subject-matter experts to assess content accuracy, presentation quality, and technical feasibility. Revisions were carried out based on expert suggestions to improve product quality.

The Implementation phase involved a limited trial at SMK Negeri 1 Sijunjung with 36 Grade XI students and two subject teachers. The developed module was implemented in classroom learning activities, and both teachers and students completed practicality questionnaires to evaluate usability, content clarity, and instructional effectiveness [18]. Finally, the Evaluation phase focused on analyzing validation and practicality data using descriptive quantitative techniques to determine the feasibility of the developed electronic module. The results of the evaluation were then used to draw conclusions regarding the module's suitability as an effective learning medium.

## 2.2 Data Collection and Analysis

Data collection in this study was conducted systematically to ensure the reliability and validity of findings related to the development and implementation of the interactive e-module for the Wired and Wireless Network Technology subject. Multiple data collection methods were employed, including classroom observations, semi-structured interviews, expert validation questionnaires, and practicality questionnaires administered to teachers and students.

Observations were conducted during classroom learning activities to identify actual learning conditions, student engagement, and the extent to which the e-module supported the learning process. Observation sheets were used to document indicators such as interaction with multimedia content, learning participation, and ease of navigation within the module.

Semi-structured interviews were conducted with selected teachers and students to obtain in-depth information regarding their experiences, perceptions, and suggestions related to the developed e-module. The interview guidelines were designed to maintain consistency while allowing participants to provide detailed responses.

Expert validation questionnaires were used to assess the validity of the e-module from both media and subject-matter perspectives. Media experts evaluated interface design, multimedia integration, navigation, and technical quality, whereas subject-matter experts focused on content accuracy, curriculum alignment, and instructional organization. A four-point Likert scale ranging from 1 (not valid) to 4 (very valid) was applied following established educational evaluation methods [19], [20].

Practicality questionnaires were administered after classroom implementation. Teachers assessed usability, instructional clarity, and efficiency in supporting classroom learning, while students evaluated user-friendliness, content clarity, engagement, and flexibility for independent learning.

Data analysis was conducted using descriptive quantitative techniques. Questionnaire responses were analyzed by calculating percentage scores to determine the levels of validity and practicality [21]. The resulting scores were categorized into four levels: very valid/very practical (81–100%), valid/practical (61–80%), quite valid/quite practical (41–60%), and not valid/not practical ( $\leq 40\%$ ).

In addition, qualitative data obtained from observations and interviews were analyzed descriptively to complement the quantitative findings. Methodological triangulation was applied to enhance the credibility and reliability of the research findings [22]. This combination of quantitative and qualitative analysis provided a comprehensive evaluation of the e-module in terms of technical feasibility, pedagogical quality, and user acceptance [23].

## 3. RESULTS AND DISCUSSION

The developed electronic module integrates various multimedia elements, including text, images, animations, audio, and video, and supports flexible access across multiple devices. This design aligns with Multimedia Learning Theory, which emphasizes that students learn more effectively when verbal and visual information are presented simultaneously through dual-channel processing mechanisms [24]. The integration of interactive multimedia components in the e-module was intended to enhance student engagement, comprehension, and independent learning experiences.

The validity test results indicate that the developed module meets both technical and pedagogical standards. Media experts assessed the module positively in terms of interface design, navigation, and multimedia integration, while subject-matter experts confirmed the appropriateness of the learning content and curriculum alignment. These findings are consistent with previous studies showing that well-designed digital learning media can improve instructional effectiveness and learner engagement [25].

In addition, the practicality test results demonstrate that the module is easy to use and supports efficient learning activities. Both teachers and students responded positively to the clarity of instructions, accessibility of materials, and flexibility of learning provided by the e-module. Similar findings have been reported in previous studies on interactive learning systems, which revealed that multimedia-based learning media contribute positively to student participation and self-directed learning.

From a theoretical perspective, the effectiveness of the developed module can also be explained using Cognitive Load Theory. This theory highlights the importance of reducing unnecessary cognitive burden during the learning process to optimize knowledge acquisition [26]. By presenting information systematically and integrating multimedia elements appropriately, the e-module minimizes excessive cognitive load and helps students focus on essential learning materials more effectively.

### 3.1. Results of E-Module Development

The result of this study was the development of an interactive electronic module for the Wired and Wireless Network Technology subject using Adobe Animate and HTML5 technology. The developed e-module integrates various multimedia components, including text, images, audio, video, and animations to support interactive learning activities. The module structure consists of a cover page, user instructions, table of contents, learning materials, practice exercises, evaluation questions, and references.

The use of the HTML5 platform allows the e-module to be accessed on various devices such as computers, laptops, tablets, and smartphones without requiring additional software installation. This flexibility supports the implementation of digital learning by enabling students to access learning materials anytime and anywhere according to their individual learning needs. In addition, the web-based format of the module facilitates easier distribution and use in both classroom and independent learning activities. Students can repeatedly review learning materials, complete exercises independently, and interact with multimedia content more efficiently. This accessibility is particularly important in vocational education, where students often require repeated practice and flexible learning opportunities to strengthen both conceptual understanding and technical competencies.

The integration of multimedia elements in the developed module is consistent with multimedia learning principles, which explain that students process verbal and visual information through separate cognitive channels to improve understanding and information retention [27]. In addition, interactive features and visual animations were designed to increase student engagement and support learning activities in vocational education contexts [28].

### 3.2. Validity Test Results

The validity of the developed e-module was evaluated by two groups of experts: media experts and subject-matter experts. A structured four-point Likert scale was employed to assess aspects such as content accuracy, curriculum alignment, instructional design, interface aesthetics, navigation, and overall technical quality. The validation results are presented in Table 1.

Table 1. E-Module Validity Test Results

Validator Type	Validation Aspect	Percentage (%)	Category
Media Expert	Interface design, navigation, media integration	84.03	Very Valid
Subject-Matter Expert	Content accuracy, curriculum alignment, material organization	93.30	Very Valid

Source: Research Data Processed by the Authors (2025).

The media experts assigned a score of 84.03%, indicating that the e-module’s interface design, navigation system, and multimedia integration met the technical and aesthetic standards required for interactive learning media. Meanwhile, the subject-matter experts provided a score of 93.30%, demonstrating that the module presents accurate and well-organized learning materials aligned with vocational curriculum standards.

These findings indicate that the developed e-module fulfills both technical and pedagogical validity criteria. This result is consistent with previous studies showing that digital learning media designed with coherent multimedia integration and user-centered instructional design tend to achieve high validity levels and positively support learning effectiveness and student engagement [29].

### 3.3. Practicality Test Results

The practicality of the developed electronic module was evaluated based on responses from teachers and students after its implementation in classroom learning activities. The assessment focused on several aspects, including ease of use, clarity of instructions, efficiency in supporting learning activities, and suitability for classroom application. The results of the practicality assessment are presented in Table 2.

Table 2. E-Module Practicality Test Results

Respondent	Percentage (%)	Category
Teachers	93.75	Very Practical
Students	88.52	Very Practical

Source: Primary Data Collected During the Study (2025).

Based on the data presented in Table 2, the electronic module obtained a practicality score of 93.75% from teachers, indicating that the module was easy to operate, supported classroom instruction effectively, and did not require complex technical skills. Meanwhile, students provided a score of 88.52%, suggesting that the module was user-friendly, well-organized, and supportive of independent learning activities.

The high practicality scores indicate that the developed e-module can be implemented effectively in classroom learning and supports both teacher-centered and self-directed learning processes. These findings are consistent with previous studies showing that practical and interactive digital learning media can improve learning flexibility, student engagement, and the effectiveness of technology-based instruction [30].

### 3.4. Student Responses

Student responses were collected to evaluate the usability and effectiveness of the developed electronic module during the learning process. The assessment focused on several aspects, including ease of use, clarity of instructional content, learning engagement, motivation, flexibility of access, and the contribution of the module to students' understanding of networking concepts. Data were obtained through student response questionnaires administered after the implementation stage. The collected responses were used to identify students' perceptions regarding the strengths and usability of the developed e-module in supporting classroom and independent learning activities.

The results indicated positive student responses toward the developed e-module. Students reported that the module helped them understand the Wired and Wireless Network Technology material more easily. Multimedia features such as instructional videos, animations, interactive quizzes, and audio narrations supported students in visualizing networking concepts that are often difficult to understand through conventional learning methods.

Students also responded positively to the interactive features integrated into the module. The use of quizzes, animations, and multimedia elements increased learning engagement and reduced learning monotony during classroom activities. These findings are consistent with previous studies showing that multimedia-based learning media can improve student engagement, motivation, and learning satisfaction [31].

Another important finding was the flexibility of the e-module. Students were able to access learning materials both inside and outside the classroom, allowing them to study independently according to their individual learning pace. This flexibility supports self-directed learning and provides students with opportunities to review learning materials repeatedly when needed.

In addition, students considered the e-module effective in connecting theoretical understanding with practical applications. Interactive exercises and simulations helped students apply networking concepts in learning activities, thereby supporting the development of both conceptual understanding and practical skills in vocational education. Overall, student responses indicate that the developed e-module supports cognitive, motivational, and practical aspects of learning through the integration of multimedia features, interactive content, and flexible learning access.

### 3.5. Discussion

The findings of this study indicate that the developed electronic module meets the validity and practicality criteria required for digital learning media in vocational education. The high validity scores show that the module is appropriate in terms of content accuracy, instructional design, multimedia integration, and technical quality. In addition, the practicality results indicate that the module is easy to use and supports learning activities effectively for both teachers and students.

The effectiveness of the developed e-module can be explained through the Cognitive Theory of Multimedia Learning, which states that students process visual and verbal information through separate cognitive channels to improve understanding and information retention [32]. In this study, multimedia components such as animations, videos, images, and audio explanations were integrated to support students in understanding networking concepts more clearly. This finding is also consistent with Cognitive Load Theory, which emphasizes the importance of presenting instructional materials systematically to reduce unnecessary cognitive burden during learning activities [33].

The results of this study also indicate that multimedia-based learning media can increase student engagement and support independent learning. Students were able to access learning materials flexibly and repeat learning activities according to their individual learning pace. These findings are consistent with previous studies showing that interactive digital learning media contribute positively to student engagement, motivation, and learning effectiveness [34].

In the context of vocational education, the developed e-module was specifically designed to support practical learning activities in the Computer and Network Engineering program. The integration of simulations, multimedia content, and interactive exercises helped students connect theoretical concepts with practical applications. This approach supports competency-based learning, which is essential in vocational education environments.

The implementation of the ADDIE model also contributed to the systematic development of the e-module. Each stage of development, including analysis, design, development, implementation, and evaluation, was conducted according to instructional needs and classroom conditions. The involvement of teachers and students during the development and implementation stages helped improve the usability and relevance of the learning media.

Overall, the developed e-module demonstrates potential as an alternative digital learning resource for vocational education. The module supports flexible learning, improves student engagement, and facilitates independent learning activities. Future studies are recommended to examine the effectiveness of the module in improving learning outcomes and to explore the integration of more advanced technologies, such as virtual laboratories or augmented reality, in vocational learning environments.

## 4. CONCLUSION

This study developed an interactive electronic module based on the ADDIE model for the Wired and Wireless Network Technology subject for Grade XI students of Computer and Network Engineering at SMK Negeri 1 Sijunjung. The results showed that the developed e-module met the validity and practicality criteria, indicating that it is suitable for use as a digital learning medium in vocational education.

The integration of multimedia elements such as text, images, videos, animations, audio, and interactive exercises supported more flexible and student-centered learning activities. The developed e-module enabled students to access learning materials more easily and interactively through various digital devices. In addition, multimedia features integrated into the module helped students understand networking concepts more clearly and increased learning engagement during classroom activities. The availability of interactive exercises and practice activities also supported independent learning processes by allowing students to review learning materials repeatedly according to their individual learning pace and needs.

However, this study still has several limitations. The implementation of the e-module was conducted only in one vocational high school and focused specifically on the Wired and Wireless Network Technology subject. Furthermore, the evaluation process was limited to validity and practicality aspects, so the effectiveness of the module in improving student learning outcomes, critical thinking skills, and long-term competency achievement has not been examined comprehensively. Technical factors such as internet availability, device specifications, and students' digital literacy levels may also influence the optimal implementation of the e-module in different educational environments.

Therefore, further studies are recommended to investigate the effectiveness of the developed e-module using larger research samples and broader implementation settings. Future research may also develop similar interactive modules for other vocational subjects and integrate additional features such as offline accessibility, automated assessment systems, adaptive learning support, virtual simulations, or augmented reality technologies. These improvements are expected to enhance the quality, flexibility, and wider implementation of digital learning media in vocational education environments.

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