

Development of Web-Based Interactive Learning Media for Computer Networking Learning

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Abstract

The rapid development of digital technology has encouraged the integration of interactive learning media to improve students' understanding of abstract concepts. This study aimed to develop a web-based interactive learning media for Computer Networking subjects and evaluate its validity, practicality, and effectiveness in improving students' conceptual understanding. The study employed the Research and Development (R&D) method using the Four-D (4D) model, consisting of Define, Design, Develop, and Disseminate stages. The participants included one material expert, one media expert, one vocational school teacher, and 30 tenth-grade students of SMK Al-Muhammad Cepu. Data were collected through observations, interviews, validation sheets, practicality questionnaires, and pretest-posttest assessments. The developed learning media integrates digital learning materials, instructional videos, interactive quizzes, automatic scoring, and learning progress reports within a web-based platform. The validation results indicated that the media achieved an average score of 4.38 from the media expert and 4.50 from the material expert, both categorized as highly valid. Practicality assessment showed excellent results, with teacher and student responses reaching 100% and 88.4%, respectively. Furthermore, the effectiveness test produced an N-Gain score of 0.91, indicating a high improvement in students' conceptual understanding. These findings demonstrate that the developed web-based interactive learning media is valid, practical, and effective for supporting Computer Networking learning in vocational high schools.

Keywords: interactive learning media, web-based learning, computer networking, vocational education, learning media

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1. Introduction

The rapid advancement of information and communication technology has significantly transformed educational practices, particularly in vocational education (Handayani & Suryani, 2022; Mayer, 2024). The integration of digital technology into learning enables teachers to deliver instructional materials through interactive media that combine text, images, animations, videos, and assessments in a single platform (Çeken & Taşkın, 2022; Mayer, 2024). Such learning environments encourage active student participation, improve learning motivation, and facilitate a deeper understanding of abstract concepts (Çeken & Taşkın, 2022; Mayer, 2024). Therefore, the development of interactive learning media has become an important strategy to improve the quality of teaching and learning in the digital era.

Computer Networking is one of the core subjects in the Information Technology program at vocational high schools. The subject requires students to understand both theoretical concepts and practical skills, including network topology, IP addressing, subnetting, file sharing, and printer sharing. These topics are often considered difficult because they involve abstract

concepts that cannot be easily visualized through conventional teaching methods (Dewi, 2023; Islapirna et al., 2023). Consequently, students frequently experience misconceptions and have difficulty applying networking concepts in practical situations (Islapirna et al., 2023).

Based on observations and interviews conducted with the Computer Networking teacher at SMK Al-Muhammad Cepu, the learning process was still dominated by PowerPoint presentations and printed learning materials. Interactive learning media had not been optimally implemented, resulting in limited student engagement during classroom activities. Furthermore, preliminary observations showed that many students experienced difficulties in understanding IP addressing, subnetting, and network topology. The pretest results also indicated that only a small proportion of students achieved satisfactory scores, demonstrating the need for more innovative instructional media to improve conceptual understanding.

Previous studies have reported that web-based learning media can improve learning outcomes and student engagement (Ferdiansyah & Irfan, 2021; Pertiwi & Irfan, 2021; Samo et al., 2023). Interactive multimedia enables students to learn independently while providing

immediate feedback during the learning process (Mayer, 2024; Ferdiansyah & Irfan, 2021). However, most existing studies focus primarily on presenting learning materials and simple evaluation features. Comprehensive web-based learning media integrating digital learning materials, instructional videos, interactive quizzes, automatic assessment, and learning progress reports within a single platform remain limited, particularly for Computer Networking subjects in vocational education.

To address this gap, this study developed a web-based interactive learning media using the Four-D (4D) Research and Development model. The developed system integrates digital learning content, interactive multimedia, formative and summative assessments, automatic scoring, and learning progress reports into a single web-based platform that supports both teachers and students throughout the learning process.

Therefore, this study aims to develop a web-based interactive learning media for Computer Networking subjects, evaluate its validity and practicality, and determine its effectiveness in improving students' conceptual understanding. The findings are expected to contribute to the development of innovative digital learning media and provide an effective alternative for improving learning quality in vocational education.

2. Methods

This study employed the Research and Development (R&D) method to develop a web-based interactive learning media for Computer Networking subjects. R&D was selected because it is specifically designed to produce educational products while simultaneously evaluating their quality through systematic testing. The development process adopted the Four-D (4D) model proposed by Thiagarajan, Semmel, and Semmel (Aimmah & Amin, 2025), which consists of four stages: Define, Design, Develop, and Disseminate. This model was selected because it provides a systematic framework for identifying learning needs, designing instructional products, validating product quality, and evaluating their implementation in educational settings. Through this approach, the developed learning media was expected to achieve high validity, practicality, and effectiveness in improving students' conceptual understanding.

2.1 Research Design

The development process followed four sequential stages. During the Define stage, a preliminary analysis was conducted to identify instructional problems through classroom observations and interviews with the Computer Networking teacher at SMK Al-Muhammad Cepu. Curriculum analysis, learner analysis, concept analysis, and learning objective analysis were also carried out to determine the competencies, learning materials, and students' characteristics. The results of this stage indicated that students experienced difficulties in understanding abstract networking

concepts, particularly IP Addressing, Subnetting, Network Topology, File Sharing, and Printer Sharing. The Design stage focused on preparing the learning media prototype. Learning materials were organized according to the independent curriculum, followed by designing storyboards, navigation structures, user interface layouts, multimedia components, interactive quizzes, and assessment instruments. The developed media integrated digital learning materials, animations, instructional videos, interactive exercises, automatic scoring, and learning progress reports into a web-based learning environment.

The Develop stage involved implementing the designed media and evaluating its quality through expert validation and field testing. Validation was conducted by one material expert and one media expert to assess content accuracy, instructional quality, interface design, functionality, and usability. Suggestions provided by the validators were used to revise and improve the product before classroom implementation. Practicality testing was subsequently conducted involving one Computer Networking teacher and thirty Grade X students to evaluate ease of use, attractiveness, and user satisfaction.

Finally, the Disseminate stage was carried out through limited implementation of the developed learning media in classroom learning activities. The dissemination process aimed to introduce the product to teachers and students while evaluating its effectiveness in improving students' conceptual understanding through pretest and posttest assessments.

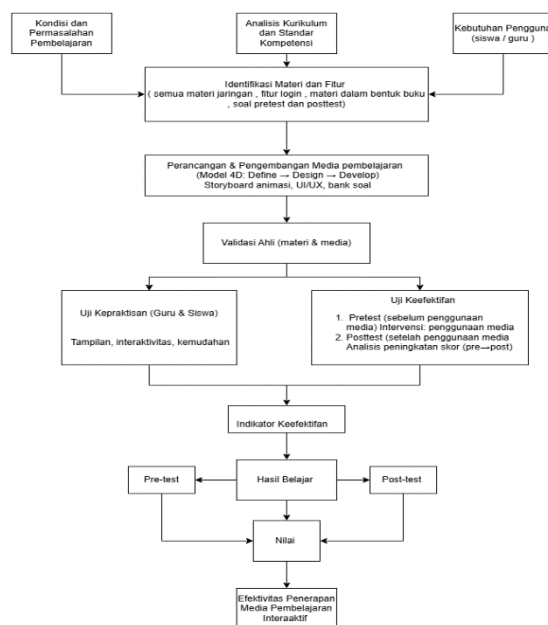


Figure 1. Research procedure based on the Four-D (4D) development model.

2.2 Research Participants

The research was conducted at SMK Al-Muhammad Cepu during the 2025/2026 academic year. The participants consisted of one material expert, one media expert, one Computer Networking teacher, and thirty Grade X students. Expert validators were responsible for assessing the validity of the developed learning media, while the teacher and students participated in practicality and effectiveness testing.

Table 1. Research Participants

Participants	Number
Material Expert	1
Media Expert	1
Computer Networking Teacher	1
Grade X Students	30

2.3 Research Instruments

Several research instruments were employed to collect the required data. Classroom observations and interviews were conducted during the preliminary study to identify instructional problems and user requirements. Expert validation sheets were used to evaluate the content quality and media design of the developed product. Practicality questionnaires were administered to teachers and students to measure usability, attractiveness, and ease of use. Furthermore, pretest and posttest instruments were employed to determine the effectiveness of the developed learning media in improving students' conceptual understanding.

2.4 Data Analysis

The collected data consisted of qualitative and quantitative data. Qualitative data were obtained from observations, interviews, and expert suggestions, while quantitative data were obtained from validation scores, practicality questionnaires, and students' learning outcomes. The validity of the developed learning media was determined based on expert validation scores. Practicality was analyzed using teacher and student response questionnaires expressed as percentages. The effectiveness of the learning media was evaluated by comparing students' pretest and posttest scores using the Normalized Gain (N-Gain) formula (Sari et al., 2021).

$$g = \frac{Sp_{post} - Sp_{pre}}{Sm_{maks} - Sp_{pre}}$$

The N-Gain score was interpreted according to three categories: high (≥ 0.70), moderate (0.30–0.69), and low (< 0.30). In addition, the reliability of the research instruments was examined using Cronbach's Alpha (Yusup, 2021) to ensure the consistency of the collected data. The combination of validity, practicality, reliability, and effectiveness analyses provided comprehensive evidence regarding the quality of the developed web-based interactive learning media.

3. Results and Discussions

3.1 Development of Web-Based Interactive Learning Media

This study developed a web-based interactive learning media for Computer Networking subjects using the Four-D (4D) development model. The development process produced a learning platform integrating digital learning materials, instructional videos, interactive quizzes, automatic scoring, and learning progress reports. The media was designed to support independent learning while assisting teachers in monitoring students' learning outcomes. The user interface was developed to provide simple navigation and interactive features suitable for vocational high school students.

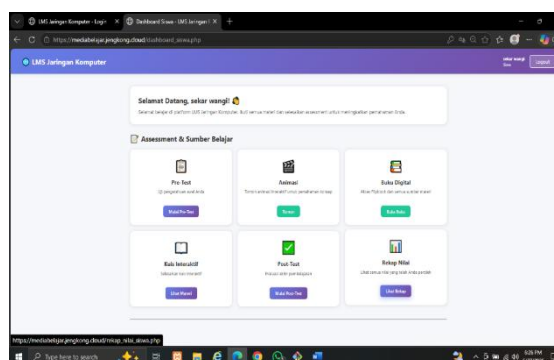


Figure 2. Home page of the developed web-based interactive learning media.

The developed learning media consists of several main features, including user authentication, learning materials, interactive quizzes, pretest and posttest, score reports, and downloadable learning resources. These features were designed to improve students' learning engagement and facilitate conceptual understanding of Computer Networking topics.

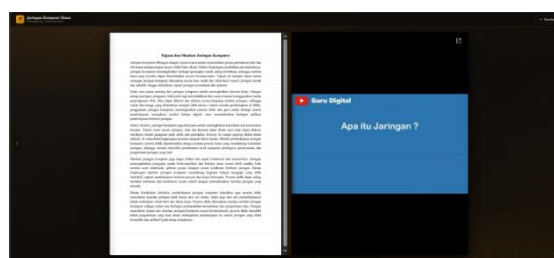


Figure 3. Learning material interface

3.2 Validation Results

The developed learning media was evaluated by one material expert and one media expert. The material expert assessed the appropriateness of learning objectives, content accuracy, presentation quality, and instructional aspects. Meanwhile, the media expert evaluated interface design, usability, navigation, functionality, and visual appearance.

Table 2. Expert Validation Results

Validator	Average Score	Category
Material Expert	4.50	Highly Valid
Media Expert	4.38	Highly Valid

The validation results indicate that the developed learning media meets the validity requirements and can be implemented in classroom learning. Suggestions provided by the validators were incorporated into the product revision before field implementation.

3.3 Practicality Results

The practicality of the developed learning media was evaluated through teacher and student response questionnaires after classroom implementation.

Table 3. Practicality Results

Respondents	Percentage	Category
Teacher	100%	Highly Practical
Students	88.4%	Highly Practical

The teacher's responses indicated that the developed media was easy to use and effectively supported classroom instruction. Student responses also demonstrated that the learning media was attractive, interactive, and helpful in understanding Computer Networking concepts.

3.4 Effectiveness Results

The effectiveness of the developed learning media was evaluated using pretest and posttest scores.

Table 4. Students' Learning Outcomes

Assessment	Mean Score
Pretest	54.00
Posttest	96.17
N-Gain	0.91

The obtained N-Gain score of 0.91 falls within the high category, indicating a substantial improvement in students' conceptual understanding after using the developed learning media.

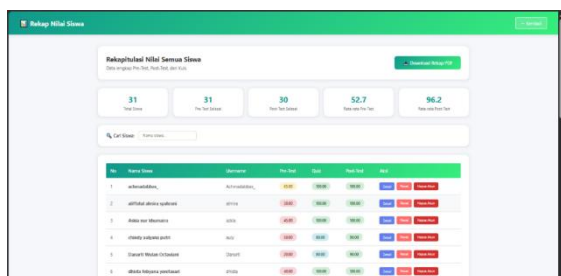


Figure 4. Comparison of pretest and posttest scores.

These findings indicate that the integration of multimedia elements, interactive learning activities, and automatic assessment successfully improved students' conceptual understanding (Mayer, 2024; Çeken & Taşkın, 2022). The results are consistent with previous studies reporting that web-based interactive learning environments contribute positively to learning achievement and student engagement (Ferdiansyah & Irfan, 2021; Islapirna et al., 2023; Pertiwi & Irfan, 2021). Furthermore, the developed learning media provides a comprehensive learning environment by integrating instructional content, formative assessment, and learning progress reports into a single platform.

3.5 Discussion

The findings demonstrate that the developed web-based interactive learning media is valid, practical, and effective for Computer Networking learning. The high validation scores indicate that both instructional content and interface design satisfy educational quality standards. The practicality results suggest that teachers and students can easily utilize the developed media during classroom instruction. Moreover, the high N-Gain score confirms that the developed learning media effectively enhances students' conceptual understanding.

Compared with previous studies (Ferdiansyah & Irfan, 2021; Islapirna et al., 2023; Pertiwi & Irfan, 2021), this research provides a more comprehensive learning platform by integrating digital learning materials, instructional videos, interactive quizzes, automatic scoring, and learning progress reports within a single web-based system. This integration represents the main contribution of the study, enabling teachers to monitor learning progress while providing students with interactive and independent learning experiences. Although this research was implemented in one vocational school with a limited number of participants, the findings indicate that the developed learning media has considerable potential for wider implementation in vocational education. Future studies are recommended to involve larger samples from different schools and to integrate adaptive learning technologies and artificial intelligence to further improve personalized learning experiences.

4. Conclusions

This study successfully developed a web-based interactive learning media for Computer Networking subjects using the Four-D (4D) Research and Development model. The developed media integrates digital learning materials, instructional videos, interactive quizzes, automatic scoring, and learning progress reports into a single learning platform that supports both teachers and students. The evaluation results demonstrate that the developed learning media achieved high validity, with average validation scores of 4.50 from the material expert and 4.38 from the media expert. The practicality assessment also showed

excellent results, as indicated by teacher and student response scores of 100% and 88.4%, respectively. Furthermore, the effectiveness test revealed a high N-Gain score of 0.91, indicating that the developed learning media significantly improved students' conceptual understanding of Computer Networking concepts. These findings confirm that the developed learning media is valid, practical, and effective for implementation in vocational high schools. The main contribution of this research lies in the integration of interactive multimedia, digital learning resources, automatic assessment, and learning progress monitoring into a comprehensive web-based learning environment. This integrated approach not only enhances students' learning experiences but also supports teachers in managing classroom learning more efficiently. Although the study was conducted in a single vocational school with a limited number of participants, the results indicate considerable potential for broader implementation. Future research is recommended to involve larger participant groups from different educational institutions and to incorporate adaptive learning technologies and artificial intelligence features to further enhance personalized learning and instructional effectiveness.

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