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Development of Renewable Energy–Based Electrical Instructional Media Using ADDIE Model to Improve Applied Science Concept Understanding among D3 Technika Students

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Abstract: This study aimed to develop renewable energy–based electrical instructional media in the form of a practicum kit and an e-module and to examine their feasibility and effectiveness in improving applied science concept understanding among vocational students. The study employed a Research and Development approach using the ADDIE model, which includes analysis, design, development, implementation, and evaluation stages. The instructional media were validated by 2 expert reviewers to assess content suitability, instructional design, technical quality, and media integration. The effectiveness of the media was evaluated through a pretest–posttest design involving 28 students of a Diploma (D3) Technika program. Data were analyzed descriptively, and learning improvement was measured using the normalized gain (N-gain). The results showed that the developed practicum kit and e-module achieved a very feasible category based on expert validation, with an average validation score of 88%. Furthermore, students' applied science concept understanding improved after using the instructional media, as indicated by an N-gain in the medium category (0.59). Students also provided very positive responses toward the usability and relevance of the media. These findings indicate that renewable energy–based practicum kits and e-modules are feasible and effective instructional media for supporting applied science learning in vocational electrical education, contributing to the enhancement of practical skills and theoretical understanding in the D3 Technika curriculum.

Keywords: Vocational Education; Electrical Learning Media; Renewable Energy; Practicum Kit; Applied Science.

Introduction

Vocational education plays a strategic role in preparing human resources with conceptual understanding and applied skills that are relevant to workplace demands. In the context of electrical engineering education, vocational students are required not only to comprehend fundamental scientific concepts but also to relate them to practical applications in electrical systems and energy technologies. Therefore, effective learning in vocational education should be designed to bridge theoretical concepts and real-world practice in order to foster meaningful understanding of applied science concepts (OECD, 2019).

Instructional media play a critical role in facilitating students' conceptual understanding through visualization, simulation, and concrete learning experiences (Arsyad, 2017). Learning activities dominated by theoretical explanations without adequate instructional media often lead to difficulties for students in visualizing abstract electrical concepts. Implementation of integrated practicum media allows students to directly explore technical variables, which has been proven to significantly enhance cognitive

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retention in electrical engineering education (Kularatna & Jayananda, 2021).

Furthermore, integrating renewable energy contexts into science learning has been shown to strengthen the connection between theoretical concepts and real-life phenomena, as it provides authentic examples of electrical applications and supports sustainable development goals (IRENA, 2020; Bybee, 2013). The integration of renewable energy in education is a strategic necessity to equip graduates with green technology competencies that are adaptive to global climate change (Walker & Cass, 2017).

However, the integration of renewable energy as a learning context in vocational education has not been sufficiently supported by the availability of systematically designed instructional media that align with the specific characteristics of vocational students. Previous studies indicate that the development of contextual and learner-centered instructional media is essential to improve the effectiveness of applied science learning (Branch, 2009; Daryanto, 2016). The transformation of learning media into digital formats, such as e-modules, provides access flexibility that supports self-paced learning models, enabling students to master complex materials outside of formal classroom hours (Ally, 2019). Despite this, there is a lack of renewable energy–based electrical instructional media specifically tailored for Diploma (D3) Technika students, which limits the potential for active and meaningful learning processes.

To address this gap, the development of electrical instructional media that integrates renewable energy concepts is expected to provide vocational students with more contextual and application-oriented learning experiences. Instructional media tailored to the characteristics of vocational education can help students understand the relationship between scientific concepts and their applications in the electrical field (Susilawati et al., 2019). Based on these considerations, this study aims to develop renewable energy–based electrical instructional media suitable for vocational education and to examine their effectiveness in improving vocational students' understanding of applied science concepts.

Method

Research Design

This study employed a Research and Development (R&D) design aimed at developing renewable energy–based electrical instructional media and examining its feasibility for use in vocational education. The R&D approach was selected because it is appropriate for producing instructional products and evaluating their quality and effectiveness in real learning contexts. The development model used in this study was ADDIE, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was chosen due to its systematic and flexible structure, making it suitable for instructional media development in vocational education

Research Site and Participants

The study was conducted at a vocational higher education institution offering a Diploma (D3) program in the Technika Department. The participants were 28 vocational students enrolled in an electrical-related course. One class was involved as the trial group, which was considered sufficient to represent the characteristics of vocational students for evaluating the feasibility and initial effectiveness of the developed instructional media. In addition to students, expert validators were involved in the study. The validators consisted of 2 experts: one Instructional Media Expert and one Subject-Matter Expert in electrical or applied science. Their role was to assess the instructional media in terms of content accuracy, instructional design, and technical quality.

Development Procedures

The instructional media were developed following the stages of the ADDIE model, as described below:

Analysis: The analysis stage aimed to identify learning problems, the characteristics of vocational students, and the need for instructional media in electrical learning. The analysis focused on the need for instructional media that integrate electrical concepts with renewable energy contexts in an applied manner.

Design: The design stage involved formulating learning objectives, organizing learning materials, designing the media layout, and planning learning activities. The design process considered the characteristics of vocational learning and emphasized strengthening students' understanding of applied science concepts.

Development: During the development stage, the instructional media were produced based on the established design. The developed practicum kit and e-module were then validated by expert validators. Revisions were made according to the validators' suggestions to improve the quality of the instructional media.

Implementation: The revised instructional media were implemented in electrical learning activities for vocational students. At this stage, the practicum kit and e-module were used as learning support tools to facilitate students' understanding of applied science concepts.

Evaluation: The evaluation stage aimed to determine the feasibility and effectiveness of the developed instructional media. Evaluation was conducted based on expert validation results and students' applied science

concept understanding after using the instructional media.

Research Instruments

The instruments used in this study consisted of three types: expert validation sheets, a test of applied science concept understanding, and a student response questionnaire.

1. *Expert Validation Sheet*

The expert validation sheet was used to evaluate the feasibility of the developed instructional media. The validation was conducted by three experts, consisting of a subject matter expert, an instructional design expert, and a media expert. The validation instrument consisted of 15 assessment items covering three aspects: content feasibility, instructional design, and technical/media aspects. Each item was assessed using a 5-point Likert scale ranging from 1 (very poor) to 5 (very good). The results of expert validation were analyzed descriptively to determine the level of feasibility of the developed media.

2. *Applied Science Concept Understanding Test*

The test instrument was used to measure students' understanding of applied science concepts related to renewable energy–based electrical systems before and after using the instructional media. The test consisted of 20 multiple-choice questions that were administered in the form of pre-test and post-test. Prior to implementation, the test items were examined through content validity by experts and tested for reliability using Cronbach's Alpha.

3. *Student Response Questionnaire*

The student response questionnaire was used to determine the practicality and student perceptions of the developed instructional media. The questionnaire consisted of 10 statements covering aspects of media usability, clarity of material presentation, attractiveness of the media, and ease of understanding the concepts. Responses were measured using a 5-point Likert scale, ranging from strongly disagree to strongly agree.

Data Analysis Techniques

Data obtained from expert validation were analyzed descriptively to determine the feasibility level of the instructional media. Pretest and posttest data were analyzed using quantitative descriptive analysis by comparing the mean scores. The improvement in students' understanding of applied science concepts was calculated using the normalized gain (N-gain) formula. The N-gain values were interpreted using Hake's categories (high: N-gain ≥ 0.7, medium: 0.3 < N-gain < 0.7, low: N-gain ≤ 0.3). Data from the student response questionnaires were analyzed descriptively to describe students' responses to the instructional media.

Result and Discussion

This section presents the results of the study, which include: (1) the feasibility of the developed instructional media, (2) the effectiveness of the instructional media, and (3) students' responses to the use of the instructional media.

Feasibility of the Instructional Media

The feasibility of the instructional media was evaluated through expert validation involving a media expert and a subject-matter expert in electrical and applied science. The validation was conducted using a Likert-scale validation sheet covering aspects of content suitability, instructional design, technical quality, and the integration between the practicum kit and the e-module.

Table 1. Results of Expert Validation of the Instructional Media

Aspect	Maximum Score	Obtained Score	Percentage (%)	Category
Content suitability	20	18	90	Very Feasible
Concept clarity	20	17	85	Very Feasible
Instructional design	20	18	90	Very Feasible
Technical and visual quality	20	17	85	Very Feasible
Integration of practicum kit and e-module	20	18	90	Very Feasible
Average	100	88	88	Very Feasible

As shown in Table 1, the developed instructional media achieved an average feasibility score of **88%**, which falls into the very feasible category. Therefore, the instructional media are considered suitable for implementation in vocational electrical learning.

Effectiveness of the Instructional Media

The effectiveness of the instructional media was determined based on students' improvement in applied science concept understanding, measured through pretest and posttest scores. The tests were administered before and after the implementation of the practicum kit and e-module in the learning process.

Table 2. Descriptive Statistics of Pretest and Posttest Scores

Test	Minimum	Maximum	Mean
Pretest	40	55	46.2
Posttest	70	85	77.8

Table 2, indicates an increase in the mean score from 46.2 in the pretest to 77.8 in the posttest after the use of the instructional media. To determine the level of improvement in students' understanding of applied science concepts, the normalized gain (N-gain) was calculated.

Table 3. N-gain Analysis Results

Mean Pretest	Mean Posttest	N-gain	Category
46.2	77.8	0.59	Medium

Based on Table 3, the N-gain value of 0.59 is categorized as medium, indicating that the practicum kit and e-module are effective in improving students' understanding of applied science concepts.

Students' Responses to the Instructional Media

Students' responses to the developed instructional media were collected using a response questionnaire administered after the learning activities. The questionnaire assessed aspects related to usability, clarity, media integration, attractiveness, and relevance to vocational learning.

Table 4. Students' Responses to the Instructional Media

Aspect	Percentage (%)	Category
Ease of use of the practicum kit	86	Very Positive
Clarity of the e-module	84	Very Positive
Integration of practicum kit and e-module	88	Very Positive
Students' interest	85	Very Positive
Relevance to vocational learning	87	Very Positive
Average	86	Very Positive

The results presented in Table 4 show that the instructional media received an average response score of **86%**, which is categorized as very positive. This indicates that the practicum kit and e-module are well received by students and support the learning process in vocational electrical education.

Discussion

Feasibility of the Instructional Media The expert validation results indicate that the renewable energy–based instructional media, consisting of a practicum kit and an e-module, are categorized as very feasible (88%). This finding suggests that the developed media meet essential criteria, including content suitability, concept clarity, instructional design, technical quality, and integration between the practicum kit and the e-module (Dick et al., 2015; Branch, 2009; Trianto, 2014). Media feasibility is a critical aspect in development research, as valid instructional media are a prerequisite for effective implementation in learning activities (Kemp, 1995; Reiser & Dempsey, 2017).

This finding is consistent with previous studies reporting that practicum-based and digitally supported instructional media tend to achieve high feasibility when designed in accordance with learners' characteristics and instructional objectives (Daryanto, 2016; Nugraha & Pratama, 2019). Moreover, the integration of renewable energy contexts into instructional media has been shown to enhance the relevance of applied science learning by presenting authentic applications of electrical concepts (Bybee, 2013; IEA, 2019). The high feasibility score (88%) indicates that the media are ready for implementation in vocational electrical education.

Effectiveness of the Instructional Media and N-gain Analysis The effectiveness of the instructional media in this study is reflected in the medium-category N-gain (0.59), indicating a significant improvement in students' understanding of applied science concepts after using the practicum kit and e-module. The medium-level N-gain can be attributed to several factors. First, the complexity of electrical concepts, particularly those related to renewable energy systems, requires time for students to internalize. Second, the students' prior knowledge of applied science concepts varied, which influenced the rate of conceptual change. Third, the implementation period was limited to one semester, which may not be sufficient for students to achieve high-level conceptual mastery.

The integration of practicum kit and e-module contributes to concept understanding through a complementary mechanism. The practicum kit provides hands-on, concrete experiences that allow students to observe electrical phenomena directly, which aligns with constructivist learning theory (Piaget, 1970). The e-module, on the other hand, provides structured theoretical explanations, visualizations, and self-paced learning opportunities that reinforce the practical experiences. This combination creates a "concrete-to-abstract" learning pathway, where students first experience the phenomenon physically and then connect it to theoretical concepts.

This finding supports previous research indicating that practicum-based learning enriched with digital instructional media contributes positively to students' conceptual understanding and engagement in science learning (Susilawati et al., 2019; Rahmawati & Setiawan, 2021). However, the medium-level improvement suggests that additional scaffolding or extended practice

may be needed to achieve higher gains in future implementations (Hake, 1998; Wulandari & Kusuma, 2019).

Students' Responses to the Instructional Media Students' responses, which fall into the very positive category (86%), further indicate that the developed instructional media are well received and support the learning process. This finding is consistent with previous studies suggesting that contextual, user-friendly, and industry-relevant instructional media can increase students' motivation and engagement in vocational education (IRENA, 2020; World Bank, 2018). The high response scores for "ease of use" and "relevance to vocational learning" suggest that the media align with the practical orientation of vocational education.

Theoretical and Practical Contributions This study contributes to the theoretical understanding of how integrated instructional media can support applied science learning in vocational education. The findings demonstrate that combining physical practicum with digital e-modules creates a synergistic effect that enhances conceptual understanding. This aligns with the theory of multimedia learning (Mayer, 2009), which suggests that combining visual, textual, and experiential learning materials improves cognitive processing.

Practically, this study provides a replicable model for developing renewable energy–based instructional media in vocational electrical education. The use of the ADDIE model ensures systematic development, while the integration of renewable energy contexts addresses the growing need for sustainable energy education in vocational programs (Kementerian Pendidikan dan Kebudayaan, 2017; Bappenas, 2020). Future research could explore the long-term retention of concepts using this media and its applicability across different vocational disciplines.

Overall, the findings of this study reinforce previous research highlighting the importance of developing integrated and contextual instructional media in vocational education. Renewable energy–based electrical instructional media in the form of practicum kits and e-modules can serve as an effective alternative for improving vocational students' understanding of applied science concepts, particularly when designed with attention to learners' characteristics and learning contexts (Yamin & Syahrir, 2020; Zainuddin & Keumala, 2018).

Conclusion

This study concludes that the renewable energy–based electrical instructional media developed in the form of a practicum kit and an e-module are categorized as very feasible for use in vocational education based on expert validation results. Furthermore, the instructional media are proven to be effective in improving vocational students' understanding of applied science concepts, as indicated by a medium-category N-gain value. The very positive responses from students indicate that the developed instructional media are well accepted and support contextual and application-oriented electrical learning. Therefore, the development of renewable energy–based practicum kits and e-modules can serve as a relevant instructional alternative to enhance the quality of applied science learning in vocational education.

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Author Contributions

This article was prepared by one author, Yusnidah. The author was responsible for all stages of the research and the preparation of this article, including conceptualization, data collection, data analysis, media development, and manuscript writing. The author has read and agreed to the published version of the manuscript.

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Conflicts of Interest

The author declares no conflict of interest.

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