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Development and Educational Evaluation of an Augmented Reality Module for Electrical Installation Training

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Abstract

Instruction in electrical installation requires media capable of presenting concepts in a concrete and interactive manner. Limitations in visualization media can hinder students' understanding of the abstract and technical concepts involved in electrical installations. This study aimed to develop and assess the feasibility of an Augmented Reality (AR)-based electrical installation learning module as an innovative instructional tool. The study employed the Research and Development (R&D) method using the 4D development model (define, design, develop, and disseminate). Validation was conducted by two subject matter experts and two media experts. A validation sheet utilizing a Likert scale served as the research instrument, and data were analyzed using descriptive quantitative methods based on feasibility percentages. The results indicated that the module achieved a feasibility score of 80% from subject matter experts (classified as "feasible") and 82% from media experts (classified as "highly feasible"). Based on these validation results, the AR-based electrical installation learning module is deemed suitable for use as an instructional medium. The use of AR offers the potential to provide a more contextual and engaging learning experience while helping students grasp electrical installation concepts more effectively.

***Keywords**: Learning Module, Electrical Installation, Augmented Reality*

Abstrak

Pembelajaran instalasi listrik memerlukan media yang mampu menyajikan konsep secara konkret dan interaktif. Keterbatasan media visualisasi dapat menyebabkan mahasiswa kesulitan memahami konsep instalasi listrik yang bersifat abstrak dan teknis. Penelitian ini bertujuan mengembangkan dan mengetahui kelayakan modul pembelajaran instalasi listrik berbasis *Augmented Reality* (AR) sebagai media pembelajaran inovatif. Penelitian menggunakan metode *Research and Development* (R&D) dengan model pengembangan 4D (*define, design, develop*, dan *disseminate*). Validasi melibatkan dua ahli materi dan dua ahli media. Instrumen penelitian berupa lembar validasi menggunakan skala Likert, sedangkan data dianalisis secara deskriptif kuantitatif melalui persentase kelayakan. Hasil penelitian menunjukkan bahwa modul memperoleh persentase kelayakan sebesar 80% dari ahli materi dengan kategori layak dan 82% dari ahli media dengan kategori sangat layak. Berdasarkan hasil validasi tersebut, modul pembelajaran instalasi listrik berbasis AR dinyatakan layak digunakan sebagai media pembelajaran. Pemanfaatan AR berpotensi memberikan pengalaman belajar yang lebih kontekstual dan menarik serta membantu mahasiswa memahami konsep instalasi listrik secara lebih efektif.

Kata Kunci: *Modul Pembelajaran, Instalasi Listrik, Augmented Reality*

Introduction

Vocational education plays a strategic role in preparing skilled, competent, and preparing skilled and competent graduates for the workforce, particularly in the field of electrical engineering. The learning process in electrical engineering education emphasizes not only the mastery of theoretical concepts but also the development of applied understanding that is relevant to industry needs [1]. Therefore, systematic and contextual learning modules are required to facilitate students' comprehensive understanding of the subject matter. However, the implementation of learning in various educational institutions still faces several challenges, including limited instructional resources and facilities, a lack of innovative instructional media, and high occupational safety risks when learning activities are conducted directly on electrical systems [2].

Electrical installation learning is an essential component of electrical engineering education, as it aims to equip students with the ability to understand concepts, procedures, and the application of electrical installations in accordance with applicable safety standards [3]. This learning process requires strong conceptual mastery as well as in-depth applied understanding. Nevertheless, limited instructional facilities and visualization media can hinder students' understanding of electrical installation concepts, particularly those that are abstract and technically complex, thereby affecting competency attainment [4]. One solution to address these issues is the development of systematic and innovative learning modules. Learning modules function as instructional materials that contain learning objectives, theoretical foundations, conceptual illustrations, and learning evaluations to support students' independent and guided learning [5]. Well-designed learning modules can enhance conceptual understanding, strengthen the linkage between theory and application, and improve the effectiveness of the electrical installation learning process [6].

With the rapid advancement of digital technology of digital technology, the application of Augmented Reality (AR) in education has emerged as a promising overlay to improve the quality of practical learning. Augmented Reality is a technology that integrates two- or three-dimensional virtual objects into a real environment in real time [7], thereby providing a more interactive and visual learning experience [8]. In electrical installation learning, AR technology enables students to study components, circuits, and installation procedures through safe visual simulations without direct interaction with live electrical equipment [9]. Previous research has shown that AR can enhance learning achievement, motivation, engagement, and the visualization of complex STEM concepts [10], although usability and technical challenges must be considered during implementation [11], [12].

Several previous studies have shown that conventionally developed electrical installation learning modules and electric motor learning modules are feasible and effective in improving students' learning outcomes [13]. However, these studies primarily rely on conventional instructional modules and have not integrated AR technology to support the visualization of electrical installation components, circuits, and procedures. Therefore, it is necessary to develop an Augmented Reality–based electrical installation practical module that can provide a more interactive, safe, and learner-centered experience in line with the demands of 21st-century education [14].

Based on the above considerations, this study aims to design and evaluate the feasibility of an Augmented Reality–based electrical installation practical module as a learning medium

in electrical engineering education. It is expected that the developed module will effectively and innovatively enhance the quality of practical learning and improve students' technical skills.

Method

This study employed a Research and Development (R&D) method using the 4D development model, which consists of four main stages: define, design, develop, and disseminate [15]. The 4D model was selected because it is appropriate for the systematic development of instructional products and is oriented toward evaluating the feasibility and quality of the resulting product [12]. The research framework for the development of an Augmented Reality–based electrical installation learning module is illustrated in Figure 1.

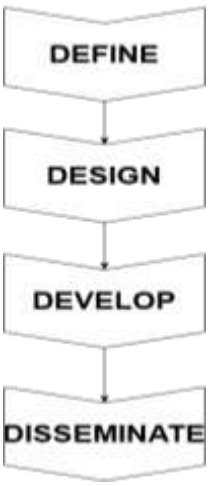


Figure 1. Research and Development (R&D) 4D Model

The define stage aims to identify learning needs in the electrical installation course through an analysis of student characteristics, learning conditions, and the limitations of conventional learning media in visualizing abstract electrical installation concepts. The results of this stage serve as the basis for determining the objectives of developing an Augmented Reality–based learning module. The design stage focuses on designing the Augmented Reality–based electrical installation learning module, including the preparation of the module structure, learning materials, visual presentation, and the integration design of Augmented Reality technology. At this stage, research instruments in the form of validation sheets for subject matter experts and media experts are also developed.

The develop stage aims to realize the module design into a learning product. The developed module is validated by two subject matter experts and two media experts to assess its feasibility in terms of content and visual appearance. The validation data are analyzed using descriptive quantitative methods and are used as the basis for revising the module according to the validators' feedback.

The disseminate stage is intended to distribute the revised learning module to the target users on a limited scale. This stage aims to introduce the module as a supporting learning medium and to obtain initial feedback regarding its readiness for broader implementation. However, in this study, the development process was limited to the develop stage due to time and cost constraints; therefore, the disseminate stage was not implemented optimally and comprehensively.

Research instruments are tools used to obtain data relevant to the research objectives. In this study, data collection instruments were employed to evaluate the feasibility of the Augmented Reality–based electrical installation practical module and to determine students' responses to its use. The instruments used consisted of validation sheets. The validation sheets were used to obtain expert assessments of the developed practical module. The evaluated aspects included module appearance, material suitability, and language use. The validation instrument grids are presented in Table 1 and Table 2.

Table 1. Media Expert Validation Instrument Grid

No	Aspect	Indicators
1	Module Size	• The module size complies with standard dimensions (e.g., ISO standard) • Margins and paper size are appropriately configured
2	Module Cover	• The cover illustration effectively represents the module's content • Typography and font usage are restrained and consistent. • The title color contrasts clearly with the background. • The proportion of title, subtitle, and text creates a professional appearance
3	Module Content Design	• Content alignment with learning objectives is well-maintained • Font variations are used moderately and consistently • Equations, formulas, and technical expressions accurately support the content. • Line spacing and character spacing ensure optimal readability • The overall layout is visually appealing and engaging

Table 2. Subject Matter Expert Validation Instrument Grid

No	Aspect	Indicators
1	Content Feasibility	• The material aligns strictly with the basic competencies and learning indicators • Content is structured systematically and logically. • Concepts are presented clearly to facilitate student comprehension • Content is designed to stimulate student curiosity and learning motivation • The difficulty level corresponds appropriately with students' cognitive readiness
2	Linguistic Appropriateness	• The language used is clear and easily accessible to students • Instructions and explanations are concise, direct, and unambiguous • Sentence structure and terminology comply with standard language guidelines
3	Presentation Aspect	• Worked examples directly illustrate and reinforce the core concepts.

		• Practice exercises align directly with the targeted learning outcomes
4	Self-Directed Learning Support	• The module actively engages students and fosters intrinsic learning motivation. • Instructions and layout effectively facilitate independent, self-paced learning.

The validation process was conducted by submitting the developed electrical installation learning module to subject matter experts and media experts. Each validator was provided with a validation sheet to assess the feasibility of the module based on predetermined aspects. The ideal feasibility score for material validation was 40, obtained from the maximum rating scale value (5) multiplied by the number of statement items (8). The ideal feasibility scores for media validation and language validation were 50, each obtained from the maximum rating scale value (5) multiplied by the number of statement items (10). These scores were used as benchmarks to determine the feasibility level of the learning module.

Data analysis in this study employed a descriptive quantitative approach. The analyzed data were derived from expert validation results. The validation data analysis was conducted to determine the feasibility level of the Augmented Reality–based electrical installation practical module based on assessments from media experts and subject matter experts. The validation data were analyzed by calculating the frequency and percentage of the obtained scores in comparison with the predetermined maximum scores. The percentage of module feasibility was calculated using the following equation:

$$Percentage = \frac{Total\ Score}{Maximum\ Score} x100 \quad (1)$$

The results of the percentage calculations were then classified into feasibility categories as presented in Table 3.

Table 3. Validation Feasibility Percentage Categories

No	Criteria	Percentage
1	Very Feasible	81 – 100
2	Feasible	61 – 80
3	Neutral	41 – 60
4	Not Feasible	21 – 40
5	Very Not Feasible	0 – 20

Result and Discussion

This study revealed in an Augmented Reality–based electrical installation learning module developed using the Research and Development (R&D) method with the 4D model, which includes the define, design, and develop stages. The results and discussion are presented based on the outputs generated at each stage of the development process.

1. Define Stage

The define stage aims to identify problems and learning needs in the electrical installation course. Based on the needs analysis, it was found that electrical installation learning still faces limitations in instructional media capable of visualizing concepts in a concrete and interactive manner. Technical and abstract electrical installation materials are often difficult for students to understand when they are delivered solely through textual explanations and static images [16]. In addition, electrical installation

learning involves occupational safety risks when conducted directly without adequate conceptual understanding. Therefore, a systematic and easily understood learning module supported by technological visualization is required to provide a safe and realistic representation of electrical installation components and procedures [17]. Based on this analysis, the development of an Augmented Reality–based learning module was selected as a solution to enhance the quality of electrical installation learning.

2. Design Stage

The design stage produced the initial design of the Augmented Reality–based electrical installation learning module. At this stage, the module structure, visual appearance, and material presentation flow were designed in accordance with the learning objectives and the characteristics of students in electrical engineering education [18].

1. Initial design of the learning module, which was developed to represent the content of the electrical installation learning module and to reflect the integration of Augmented Reality technology. The module cover includes the module title, author information, and illustrations relevant to the field of electrical installation.



Figure 2. Learning Module Design

2. Outline or framework of the learning module, which was systematically structured and consists of an introduction, learning objectives, electrical installation materials, Augmented Reality–based visualization, and learning evaluation.
3. Results of the Augmented Reality implementation, which are presented through barcode scanning on the learning module. The barcode is linked to three-dimensional electrical installation objects visualized using Augmented Reality technology. This feature allows students to view representations of electrical installation components in an interactive and contextual manner, thereby facilitating the understanding of abstract concepts. Examples of barcode scanning results and Augmented Reality object visualizations are shown in Figures 3 and 4.



Figure 3. Barcode and KWH Meter



Figure 4. Barcode and MCB

This design aims to produce a learning module with a clear structure, ease of use, and support for independent learning.

3. Develop Stage

The develop stage represents the realization of the learning module design prepared in the previous stage. At this stage, the learning module was developed into a complete product that integrates textual materials, illustrations, and Augmented Reality visualizations. The developed learning module was subsequently validated by two subject matter experts and two media experts to determine its feasibility level. The validation was conducted using validation sheets with a five-point Likert scale.

Table 4. Results of Subject Matter Expert Validation

No	Assessment Indicator	Item	Validator 1	Validator 2	Total Score	Feasible Percentage	Feasibility Criteria
1	Material Relevance	P1	4	4	8	26 %	86,67
		P2	4	5	9		
		P3	4	5	9		
2	Material Effectiveness	P1	5	4	9	55%	91,67
		P2	5	4	9		
		P3	5	5	10		
		P4	4	5	9		
		P5	4	5	9		
		P6	5	4	9		
3		P1	3	5	8	35%	87,50
		P2	3	5	8		

	Archievement of Learnign Objectives	P3	5	4	9		
		P4	5	5	10		
4	Attractiveness	P1	5	4	9	19%	95,00
		P2	5	5	10		
Overall Total					120	80.00%	Feasible

Based on the validation results from two subject matter experts, the Augmented Reality–based electrical installation learning module obtained a total score of 120 out of a maximum score of 150, resulting in a feasibility percentage of 80%, which falls into the feasible category. These results indicate that, in terms of content substance, the module meets the feasibility criteria for use in the learning process, although minor improvements are still required in accordance with the validators' suggestions.

Table 5. Media Expert Validation Results

No	Assessment Indicator	Item	Validator 1	Validator 2	Total Score	Feasible Percentage	Feasibility Criteria
1	Module Size Aspect	P1	5	5	10	20%	100,00
		P2	5	5	10		
2	Module Cover Aspect	P1	5	5	10	37%	92,50
		P2	5	5	10		
		P3	4	4	8		
		P4	5	4	9		
3	Module Content Design Aspect	P1	5	5	10	66%	94,29
		P2	4	3	7		
		P3	5	4	9		
		P4	5	5	10		
		P5	5	5	10		
		P6	5	5	10		
		P7	5	5	10		
Overall Total					123	82%	Feasible

The media expert validation results indicate that the Augmented Reality–based electrical installation learning module obtained a total score of 123, with a feasibility percentage of 82%, and was classified as feasible. The highest scores were achieved in the aspects of module size, module cover, and content design, which were rated very positively in terms of visual appearance, readability, and design consistency. Nevertheless, several assessment items still require minor revisions to further optimize the quality of the learning media. Overall, the validation results show that the learning module achieved a feasibility percentage of 80% from subject matter experts, categorized as feasible, and 82% from media experts, categorized as very feasible.

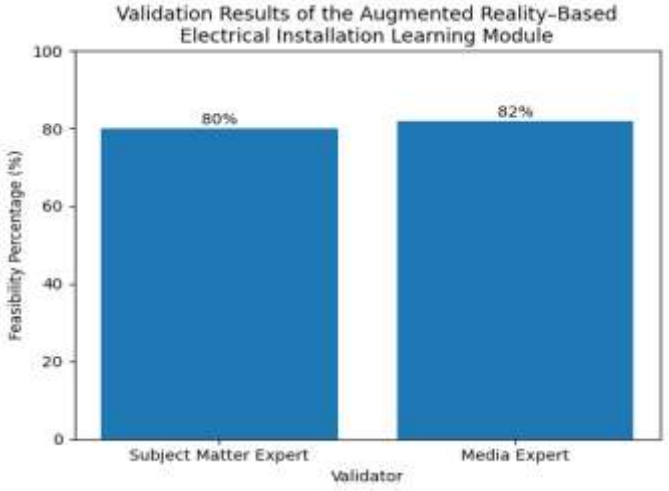


Figure 5. Validation Results of the Augmented Reality–Based Electrical Installation Practical Module

Based on Figure 5, it can be observed that the learning module achieved a high level of feasibility in both content and media aspects. The subject matter experts' assessment indicates that the content is aligned with the learning objectives and students' needs, although improvements are still required in the formulation of learning outcomes and the completeness of the materials. Meanwhile, the media experts' evaluation shows that the module demonstrates excellent visual quality, readability, and integration of Augmented Reality [19], which effectively supports the learning process. Feedback from the validators was used as the basis for revising the module, particularly in terms of enhancing content quality, ensuring visual design consistency, and improving the clarity of instructions for using the Augmented Reality features.

The results of this study indicate that the development of an Augmented Reality–based electrical installation learning module using the 4D R&D model is effective in producing a feasible and innovative learning medium [20]. The integration of Augmented Reality technology provides more realistic visualizations of electrical installation concepts that were previously difficult to understand through conventional learning media.

The difference in feasibility percentages between subject matter experts and media experts suggests that media and visualization aspects are the main strengths of this learning module, while the content aspect still requires minor improvements. These findings indicate that the development of technology-based learning modules should be balanced with the strengthening of content substance to optimize learning quality [21]. Overall, the Augmented Reality–based electrical installation learning module demonstrates strong potential to be used as an alternative learning medium in electrical engineering education.

The findings of this study are consistent with previous research indicating that technology-based learning module development is feasible and effective in improving learning quality and understanding [22]. Unlike conventionally developed electrical installation learning modules reported in earlier studies, this research offers novelty through the integration of Augmented Reality technology, which provides interactive visualizations of abstract electrical installation concepts, thereby reinforcing visual learning theory in technical education. The implications of this study suggest that the Augmented Reality–based electrical installation learning module has the potential to be utilized as a supplementary learning medium in electrical

engineering education programs, both as instructional material for lecturers and as an independent learning resource for students. Comparable findings have also been reported in AR-supported university physics laboratory and electromagnetism learning, where interactive visualization reduced extraneous cognitive load and supported students' learning experiences [23] [24].

However, this study has limitations, as the module development was conducted only up to the develop stage and was not extended to the disseminate stage due to time and cost constraints. Due of this, the impact of Augmented Reality–based learning modules affected on students' learning outcomes and motivation, as AR-assisted learning has been shown to improve both outcomes [25]. In addition, field testing was not conducted to measure the effectiveness of the module on learning outcomes. Therefore, future research is recommended to continue to the disseminate stage and to conduct large-scale implementation and field trials to examine the impact of using Augmented Reality–based learning modules on students' learning outcomes and motivation.

Conclusion

The development of an Augmented Reality–based electrical installation learning module using the 4D Research and Development (R&D) model, which includes the define, design, develop, and disseminate stages, successfully produced a learning product that is feasible for use. The learning module was developed based on the needs of electrical installation learning, which requires concrete and interactive visualization.

The validation results indicate that the module achieved a feasible category from subject matter experts with a percentage of 80% and a very feasible category from media experts with a percentage of 82%. At the disseminate stage, the module was introduced on a limited basis to the target users as a supporting learning medium. Therefore, the Augmented Reality–based electrical installation learning module can be used as an innovative alternative learning medium with the potential to enhance the quality of electrical installation learning.

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