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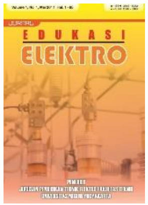

Development of Freeware-Mobile Application for Learning Electrical Installation in Vocational High Schools

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Abstract—The study aims to design and develop a freeware application for electrical installation planning analysis. This research is categorized as development research, adopting the RAPID Application Development (RAD) model. The data collection process in this study involved a series of methods, including direct observation of the learning process, in-depth interviews with potential users, and the distribution of structured questionnaires to relevant respondents. The analysis of the collected data was carried out using a quantitative descriptive method, which aimed to describe and interpret numerical data related to the performance and acceptance of the developed application. The overall results of this study indicate that the designed and developed freeware application, as a learning media for electrical installation planning analysis, demonstrates highly satisfactory performance and falls into the "Very Good " category. Specifically, the evaluation of the application's functionality aspect showed a success rate of 100%, indicating that all designed features and functions operate according to the expected specifications. Similarly, the assessment of the user interface aspect also reached a percentage of 100%, implying that the application's interface design is intuitive, easy to use, and overall provides a positive user experience. In addition, in terms of material and media feasibility, it produces "Highly Feasible". The application is determined to effectively incorporate electrical installation planning content pertaining to the learning outcomes of determining cable sizes and circuit breaker capacity. Consequently, this freeware application has significant potential to become an effective learning media in enhancing the understanding and skills of students and practitioners in the field of electrical installation planning.

Keywords: learning media, electrical installation planning, electrical lighting installation.

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1 Background

Vocational High Schools are projected to prepare students who master the affective, cognitive, and psychomotor aspects in certain fields required by the job market [1]. Vocational High Schools graduates should be able to support the development of infrastructure that is being intensively carried out in this increasingly modern life. Real conditions actually show that Vocational High Schools graduates have dominated Indonesia's open unemployment rate over the last decade, where the latest data shows a percentage of 9.01 [2]. Therefore, Vocational High Schools students are required to truly master their skills so that they become competent graduates and can be well absorbed in the industry.

The formation of student competencies should priorities three aspects of learning: the role of teachers, facilities, and learning activities. Learning media is believed to be an important component of the learning system. The use of learning media is expected to facilitate the learning process and produce better products or outputs than conventional learning methods[3].

Software learning media is one form of technology utilization in the learning process[4]. The use of technology is a wise step that can be applied in the learning process in vocational education. School communities are required to be literate or technology friendly. Learning media in the form of smartphone applications have begun to be introduced in the education field. The use of smartphone applications as learning media has several advantages, such as being a source of independent learning because it can be accessed outside of class hours, can be used for online learning, and is more visually appealing when compared to printed books[5], [6].

Decree of the Minister of Education, Culture, Research, and Technology of the Republic of Indonesia Number 244/M/2024 concerning the Spectrum of Expertise and Conversion of the Spectrum of Expertise for Vocational High Schools in the Independent Curriculum states that Electrical Power Installation Engineering is one of the Electrical Power Engineering expertise programs. Students are required to master electrical installation skills from planning to implementation. Electrical Power Installation Engineering expertise competency students begin to gain knowledge about electrical installation planning in the Electrical Lighting Installation subject. The aspects of reliability, safety, efficiency and economy in an electrical installation are determined from the planning as the initial stage [7].

Electrical installation planning includes load calculation analysis, which must consider the circuit breaker capacity and cable size used. Precise and accurate calculations are necessary in planning electrical installations, in addition to making a good and clear installation plan. Manual calculations are considered ineffective because they require a long time and process[8].

Analysis of determining the size of electrical installation materials, including cable and circuit breakers, is one of the Learning Objectives in the Learning Outcome "Electrical Lighting Installation" of the Electrical Power Installation Engineering subject. Observations of learning Electrical Lighting Installation at Vocational High Schools 4 Lubuklinggau, Vocational High Schools 2 Yogyakarta, Vocational High Schools 1 Magelang, and Vocational High Schools YPP Purworejo showed that students still had difficulty in determining the size of conductors and safety devices for electrical installations.

The body of literature suggests that mobile-based learning in vocational education has been demonstrated to extend instruction beyond traditional classrooms, thereby improving both accessibility and learning outcomes [9], [10], [11], [12], [13], [14], [15], [16]. Mobile devices enable training "regardless of time and place," allowing learners to study anytime with ubiquitous access to materials [13], [14], [15]. For example, [17] found that smartphones turn education into a "lifelong, anytime, anywhere" activity. This flexibility is particularly valuable in vocational programs where skills practice often occurs in workshops or the field. Mobile learning also boosts engagement and motivation. [18] reported that giving students active control over their learning yields "an increase in student motivation" and encourages self-directed learning. Likewise, [19] found that mobile-enabled activities significantly enhance students' motivation and help "improve learning outcomes" while making abstract concepts more concrete. In practice, these enhancements translate to better results: studies in vocational courses consistently show higher achievement when mobile tools are used. Both [19] and [17] observed that mobile-learning groups achieved significantly higher test scores than controls (ref). [20]Similarly, researchers reported that their vocational mobile app improved learner autonomy and outcomes, noting that learning was “not hampered by distance and time” [21]. Additional benefits include facilitating collaboration [22], highlighted that mobile platform support distance collaboration by allowing learners to access content “anywhere and at any time”. In summary, several studies indicate that mobile learning in vocational settings enhances accessibility, engagement, and performance, enabling anytime-anywhere study, greater learner autonomy and motivation, and better competency outcomes [19], [22].

Recent studies emphasis mobile learning's potential in vocational contexts. [21]Noted that mobile apps enable flexible "anytime-anywhere" learning with interactive features (e.g., multimedia, gamification) that boost student engagement [21]. Mobile technology also supports collaboration and easy access to resources. Importantly, such increased engagement and motivation are linked to improved academic outcomes[23]. Together, these benefits suggest mobile learning can enhance accessibility, interactivity, and performance in vocational training.

Nevertheless, A recent Indonesian survey reported that although 100% of Indonesian vocational students in some sites owned smartphones, only about 4.2% used educational apps [24], highlighting limited mobile learning uptake. In Indonesia, app-based learning in vocational schools remains scarce. For example, another recent study developed an Android learning tool for electric motor installation, but broader electrical installation planning skills are largely unaddressed [25]. These findings indicate that mobile learning media for vocational electrical competencies have been underexplored. Therefore, building on these existing research gaps, the present study’s problem is defined as: How can a mobile learning application support Vocational High Schools students’ mastery of electrical installation planning? Guided by identified teaching challenges [21] and existing app-based materials (e.g., for motor installation [25], the present research work develops an Android-based learning tool for electrical installation planning. The research objective focuses on whether and how this mobile app can improve students’ planning skills and learning outcomes in vocational electrical subjects.

In summary, the improvement of students' understanding can be optimized by using mobile-driven learning media. The use of mobile applications as learning media to analyze planning electrical installations is effective, fast, and accurate. Therefore, in this study, an electrical installation planning application was developed to assist students in conducting electrical installation planning analysis, including calculating the size of cable and circuit breaker devices used based on the installed load. This application offers a structured and integrated learning environment enabling students to engage in self-directed study of foundational concepts, perform calculations for conductors and circuit breakers, and apply their knowledge through practice problems enhanced by component installation simulations.

2 Method

This study used research and development with the RAPID Application Development (RAD) model by James Martin (1991). The RAD methodology adopts an accelerated approach akin to the linear sequential model through its emphasis on component-based construction, thereby facilitating expedited development timelines[26]. The principal benefit of leveraging RAD lies in its iterative and adaptable framework, which accommodates ongoing feedback integration and iterative modifications throughout the software development lifecycle [27]. There are four steps in the RAD model, namely the requirement planning phase, user design phase, construction phase, and cutover phase. The RAD development procedure can be seen in Figure 1.

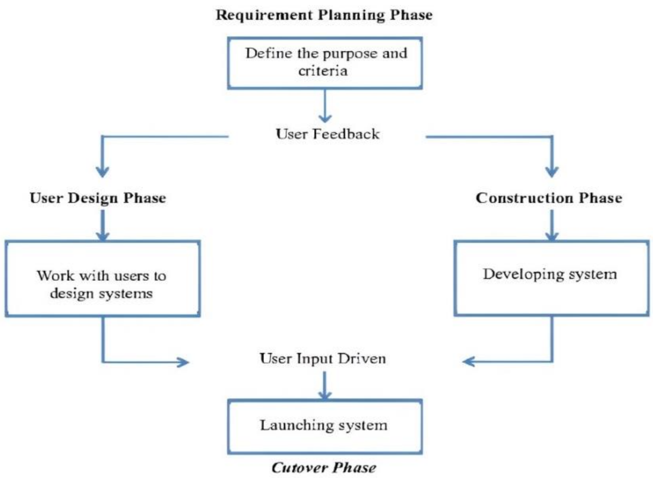


Figure 1. Development procedure

2.1 Requirements Planning Phase

This initial phase was critical for establishing a congruent understanding between the development team and stakeholders. Through systematic observation and semi-structured interviews with students, teachers, and industry practitioners, a comprehensive analysis of existing challenges was conducted. This process facilitated the collection of pertinent data and the subsequent definition of the application's core features and functionalities. An in-depth needs assessment, undertaken via observations across several vocational high schools (Vocational High Schools 4 Lubuklinggau, Vocational High Schools 2 Yogyakarta, Vocational High Schools 1 Magelang, and Vocational High Schools YPP Purworejo), revealed significant difficulties in the acquisition of electrical installation planning analysis skills, particularly in the determination of appropriate conductor and circuit breaker specifications.

The identified learning challenges stem from several interconnected factors. These include the perceived lack of sufficiently supportive instructional materials, the prerequisite foundational knowledge required for engaging in complex analysis, the predominantly manual execution of electrical installation planning calculations, and the limited availability of interactive learning media. Consequently, students often exhibit a deficit in the depth of their understanding of the subject matter. Furthermore, prevailing pedagogical approaches tend towards passive learning, underscoring the necessity for interactive learning media to enhance learning outcomes and optimise the overall effectiveness of the educational process.

To ensure the developed application's relevance and alignment with industry demands, interviews were also conducted with practitioners at CV. Metrical Engineering Pratama. These interviews aimed to elucidate current practices in electrical installation planning within the professional domain, with a specific focus on the methodologies employed for determining conductor and circuit breaker specifications. This engagement facilitated the integration of industry-relevant considerations into the application's design and functionality.

The data obtained from these interviews provided critical empirical evidence, informing the developers' decisions to incorporate the minimum specifications for conductor and circuit breakers commonly employed in practical field applications within the application's parameters. This evidence-based approach ensures the application's specifications are grounded in real-world usage. It ensures the application is not only theoretically sound but also directly applicable to the daily workflows of professionals in the field.

2.2 User Design Phase

This phase involved the materialization of the specifications defined during the planning phase. Key activities undertaken by the development team included the design of data structures, application architecture, user interface displays, and program algorithms. This process aimed to provide a comprehensive blueprint of the project under development. The user interface display was designed adhering to established user interface principles, specifically considering usability aspects as outlined in ISO 25015. Functionally, this application focuses on the determination of appropriate electrical installation cable and circuit breaker capacity, predicated on the installed load data presented within the analysis menu, as visualized in Figure 2.

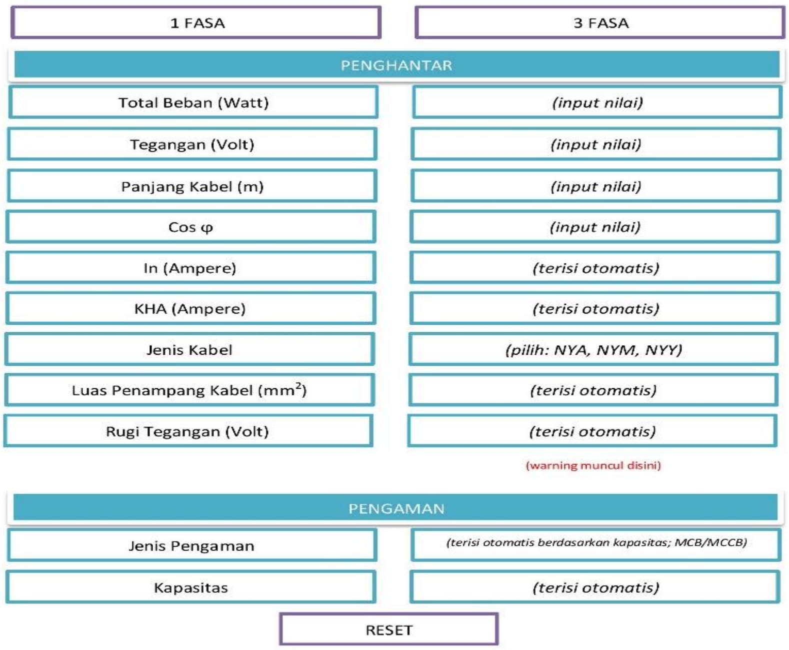


Figure 2. Design of analysis menu

The parameters of the analysis menu are comprehensively described in Table 1. This menu is engineered to generate recommendations for both cable size and circuit breaker capacity, drawing upon various input parameters such as the electrical system chosen, nominal of the electrical load, and cable length and type.

Table 1. Analysis menu

Parameter	Work Function
Electrical System	The user chooses the phase type, namely 1 phase or 3 phases
Nominal Power	The user inputs the load value of the installation, either for one group or the main group.
Voltage	The user inputs the voltage value
Cos phi	The user inputs the cos phi value of the installation with a maximum value of 1.
Cable Length	The user inputs the cable length value of the installation in meters.
Cable Type	Users choose the type of cable for installation. The cable types provided are NYA, NYM, NYY, and NYAF.
Nominal Current (In)	Based on the input values, the application will work and display the nominal current, which is the result of the application's calculations.
KHA	Based on the nominal current value, the application will work and display the KHA value automatically.
Wire Gauge	The application will work based on the KHA value and the type of cable selected, and the appropriate conductor size will be recommended for installation.

Parameter	Work Function
Circuit Breaker Rate	The application will recommend the capacity of the circuit breaker that can be used in the installation, which is the result of the application's calculations.
Circuit Breaker Type	Based on the capacity rate, the application will recommend the type of circuit breaker that can be used in the installation. The types of circuit breakers consist of MCB and MCCB. MCCB is recommended for capacities starting from 80A
Voltage Drop	Based on the input values, the application will work and display the voltage loss value, which is the result of the application's calculations.

2.3 Construction Phase

Construction is the development phase where the process of converting the design form into a language that the machine can understand is carried out. The construction stage includes application development carried out using the CodeIgniter framework, which includes coding with the C++ programming language. Testing is carried out on the system, as well as the completed code.

This phase involved parallel development of software and associated materials. The application design, represented by flow diagrams and storyboards, served as the foundational framework for this development process [28]. The flow diagram provides a sequential representation of the entire operational workflow.

2.4 Cutover Phase

The cutover phase is the application testing stage for the client to determine and measure the performance of the application learning media developed without looking at the product program. Black-Box Testing was utilized as the test method. This technique evaluates software by examining its functional behavior (inputs and outputs) against specified requirements without considering its internal structure or implementation [29]. This testing is carried out with the aim of determining whether there are errors or bugs in the application during use. Software design quality attributes are used to examine black box testing instruments with functional and interface aspects adopted from [29], [30]

The black box test score results were then analysed and converted into assessment categories determined using normal distribution intervals, as listed in Table 2, where *Mn* is the average nominal score and *SBn* is the nominal standard deviation [31].

Table 2. Grouping data into four categories

Score Interval	Category
(Mn + 1,5 SBn) – (Mn + 3 SBn)	Very Good/Highly Feasible
Mn – (Mn + 1,5 SBn)	Good/Feasible
(Mn – 1.5 SBn) - Mn	Fairly Good/Fairly Feasible
(Mn–3 SBn) – (Mn–1.5 SBn)	Not Good/Not Feasible

Beyond the application's performance evaluation via black box testing, the present study also assessed the feasibility of its material content and its viability as a learning media. The evaluation of the material's feasibility was conducted with reference to the Ministry of National Education's Teaching Materials Guide (2010). Concurrently, the assessment of the media's feasibility drew upon the ISO 25010 standard as interpreted through Pressman's theoretical framework (2014) and the Google Material Design Guidelines-Material You (2021). Feasibility data were collected using a questionnaire employing a four-point Likert scale. The resulting scores underwent descriptive analysis and were subsequently mapped onto a four-category assessment framework, as detailed in Table 2.

3 Results and Discussion

This research produces an Android-based software learning media called “Electrical Planning Installation” in .apk format. The application has a capacity of 14 MB and a resolution of 720 x 1280 pixels. It was developed using Adobe Flash CS6 software.

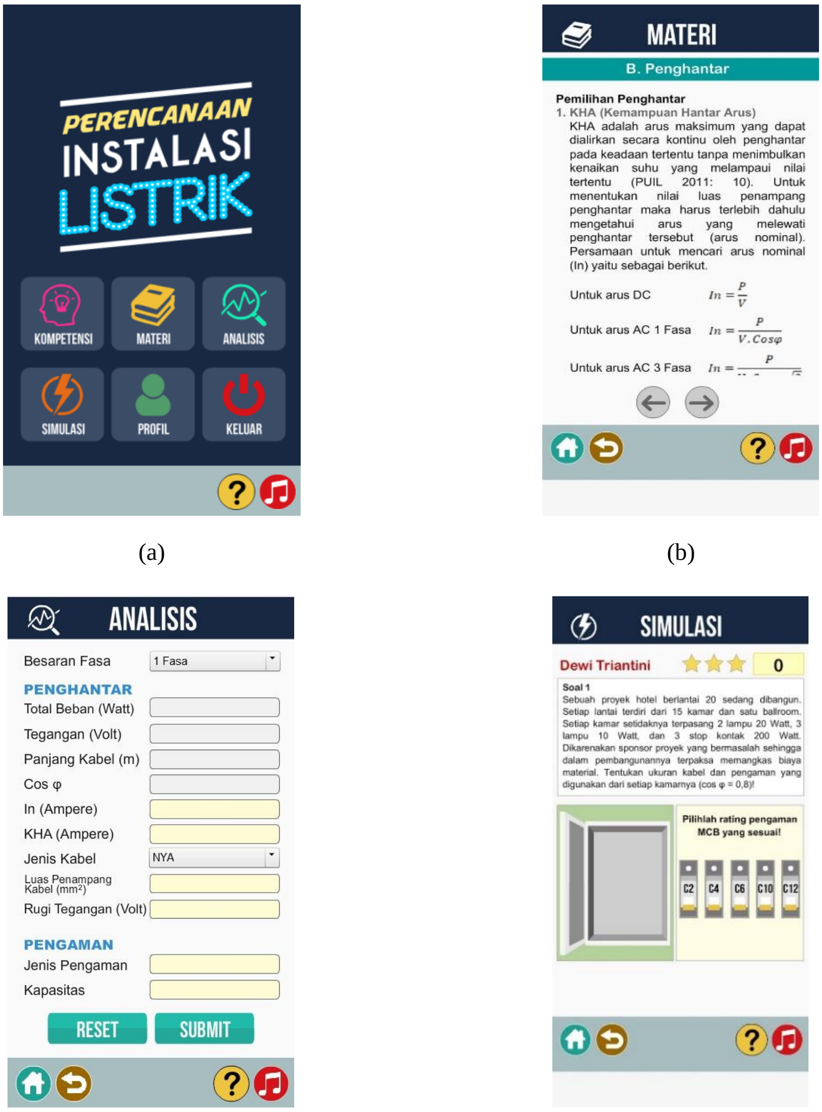
This application focuses on the analysis and calculation of material to determine the size of cable and circuit breaker capacity based on the installed load. The specifications of the product developed are as follows: (1) the application consists of 5 main menus, namely competence, material, analysis, simulation, and developer profile; (2) the material menu includes the understanding and basic concepts of electrical installations, General Requirements for Electrical Installations (PUIL), electrical loads, electrical conductors, and electrical circuit breaker; (3) the analysis menu facilitates students to find out recommendations for conductor sizes, voltage losses, types and circuit breaker ratings based on the value of the given load power; (4) the simulation menu contains practice questions that are packaged in an attractive way to deepen the material on electrical installation planning.

Upon launching the Electrical Installation Planning application, users will be presented with an initial interface featuring the application's logo as a visual identity, a concise description outlining the application's function and purpose, and an interactive element in the form of a "Start" button (Figure 3a). To proceed with application interaction, users are required to activate the "Start" button. This action will direct users to an input form prompting self-identification via name, which is subsequently confirmed through the "Enter" button to access the application's main page. The visual transition to the main page will occur instantaneously upon user confirmation via the "Enter" button (Figure 3b).

(a) (b)

Figure 3. Onboarding screens of application

Figure 4 illustrates the visual interface of the application's main page and selected menus. The material menu (Figure 4b) incorporates introductory content pertaining to electrical installation planning, with a specific focus on determining conductor size and circuit breaker capacity, developed in accordance with the Indonesian General Requirements for Electrical Installations 2020 and relevant literature [32], [33], [34].



(a) (b)

(c) (d)

Figure 4. Application display of (a) home, (b) material menu, (c) analysis menu, (d) simulation menu

During material development, a scoring rubric was implemented within the simulation menu. The simulation menu contains the exercise of determining cable types, cable sizes, and circuit breaker rates based on the installed load. The initial binary (correct/incorrect) scoring was revised to a weighted system, which assigned specific scores to each answer. Following submission via the "Submit" function, the rubric provides feedback on response accuracy. Each answer option is further elucidated by a distinct explanation pertaining to the selection of cable type, wire gauge, and circuit breaker rating. The effects of this modification are depicted in Figure 5.

(a) (b)

Figure 5. Modification of exercises feedback: (a) before; (b) after

The implementation stage of this study involved formative development trials conducted with 13 students utilizing a range of Android operating systems, specifically Android 7.0 Nougat, Android 8.0 Oreo, Android 9.0 Pie, and Android 10.0. These trials assessed the operational efficacy of the application's menus and Input/Output (I/O) panel functionalities. Data collection for this assessment was based on a black-box testing questionnaire, evaluating two key aspects: functionality and interface. Black-box testing is a software evaluation method focused on validating the functional behaviour of an application by verifying that its inputs and outputs align with the required specifications, independent of its internal implementation details.

This system testing is carried out to determine whether the system has met the formulated user needs. The assessment of the results incorporated a binary categorization; a value of 1 was assigned if the application ran well, whereas a value of 0 indicated inappropriate findings. The questionnaire comprised a total of 36 statement items, with 28 items addressing functionality and 8 items focusing on the interface. The scoring results indicated that the functionality aspect achieved a maximum score of 28, while the interface aspect attained a maximum score of 8.

Table 3. Performance test assessment score

Aspects	Average Score
Functionality	28
Interface	8

The test was conducted by giving a questionnaire to 13 respondents from a vocational high school majoring in Electrical Power Installation Engineering. The functionality aspects got a score of 364 from all respondents and a score of 104 for the interface aspect. Therefore, based on the aggregated scoring data, the mean score for the functionality aspect was determined to be 28, while the mean score for the interface aspect was calculated as 8. Quantitative performance assessment scores derived from the questionnaire are presented in Table 3. The corresponding performance assessment status was determined by converting the mean assessment score and mapping it to the criteria outlined in Table 2. Based on the collected data, the performance of both the functionality and interface aspects of the application was categorized as "Very Good."

The performance outcomes observed through black-box testing align with the conclusions of [35], [36], who established the effectiveness of this testing approach in detecting errors related to functional and user interface aspects. Their research further highlights the significance of black-box testing in assuring application reliability and functionality, which are critical attributes in educational settings where accessibility and usability are essential considerations for the target user groups of students and teachers.

The feasibility of the material was evaluated using a 54-item questionnaire, addressing both content (34 items) and learning design (20 items). Concurrently, the feasibility of the media was assessed via a distinct 35-item questionnaire, informed by ISO 25010 standards (19 items) and principles of graphic design (16 items). Each feasibility assessment involved three validators. Both questionnaires employed a Likert scale ranging from 1 to 4. The aggregated assessment scores for the feasibility tests are presented in Table 4.

Table 4. Material and media feasibility score

Material		Media	
Aspects	**Average Score**	**Aspects**	**Average Score**
Content	113	ISO 25010	71,3
Learning Design	69	Graphic Design	57,3

The raw scores obtained from each aspect of the material and media feasibility assessments were transformed according to the criteria outlined in Table 2. Following this conversion, the results indicate that both the material and the media demonstrate "Highly Feasible" characteristics. Consequently, the application program is determined to effectively incorporate electrical installation planning content pertaining to the learning outcomes of determining cable sizes and circuit breakers.

The evaluation of material expert feasibility adhered to the theoretical framework articulated by the Ministry of Education, Culture, Research, and Technology in the Learning and Assessment Guide (2024). These guidelines stipulate that the development of material content necessitates consideration of several key components: factual accuracy, conceptual precision, depth of coverage, logical sequencing, learner appropriateness, relevance to contemporary contexts, and readability.

The assessment criteria for mobile-based applications, as outlined by [37], encompass grids, typography, colour, and imagery. Similarly, [38] and [39] posit that the evaluation of an application's appearance includes colour composition, the proportional arrangement of display elements, text quality, and image quality. Furthermore, [40] details several criteria for evaluating mobile applications, namely colour selection, icon design, image presentation, text layout, and overall layout. Synthesizing these theoretical perspectives, established principles in Android-based application software development substantiate the feasibility of the Electrical Installation Planning application's learning medium.

Generally, the app’s robust functionality and user satisfaction are aligned with those in similar vocational learning studies. For example, [12] reported that Android-based interactive multimedia for electrical installation achieved very high student satisfaction. Likewise, [20] found that a mobile learning app (MOLA) significantly improved learner independence and learning outcomes in technical courses. These outcomes align with constructivist and self-regulated learning principles: interactive mobile media give students active control of contextualized tasks, boosting motivation and engagement [22], [23], [41], [42].

Furthermore, compared to existing educational apps, our application has distinct advantages for vocational electrical training. [11] found that an Electrical Wiring Simulator mobile app had high perceived usefulness and ease of use, significantly enhancing users’ potential wiring skills. Indonesian studies similarly report strong engagement: [10] describe an Android-based installation app that made lighting-installation classes "more engaging and flexible," markedly improving technical learning quality. Many current tools focus on wiring concepts or use AR-based visualization [9]. Still, our app uniquely integrates planning-oriented tasks (e.g., circuit layout design and materials costing) directly aligned with vocational curriculum competencies.

Finally, multiple implications can be derived from the findings of the present study. Pedagogically, the app supports more student-centered strategies. Teachers can use it in flipped or blended lessons, since mobile platforms enable instructors to coordinate multimedia resources and innovative activities more easily [22]. Students exhibit higher engagement and autonomy; mobile learning research finds that devices allow learners to actively control their pace of study actively, increasing motivation and self-direction [22], [23], [43]. Because the app provides anytime-anywhere access, learners can practice installation planning outside class, like the advantages noted for AR tools [9]. By mapping its exercises to vocational competencies (e.g., wiring plans and cost calculations), it integrates smoothly into the curriculum, reinforcing authentic hands-on skills in electrical installation [9], [10].

4 Conclusion, Limitations, and Future Directions

Referring to the research objective of developing interactive learning media, this study has produced a mobile application, “Electrical Installation Planning,” specifically designed to support the learning of electrical installation planning material, particularly in achieving competency indicators related to determining cable dimensions and overcurrent protection devices based on installed load. The performance evaluation of the application through black-box testing demonstrated highly positive results, categorized as "Very Good" with a 100% success rate in both functionality and user interface aspects. Meanwhile, the feasibility of both material and media is categorized as "Highly Feasible". Consequently, the development of this application is successful in providing valid and potentially effective learning media to enhance the understanding of electrical installation planning among vocational high school students.

This study has several limitations that should be acknowledged. The first is the small sample of only 13 participants, which does not confirm the generalizability of the findings about the broader educational effectiveness of the application. Secondly, this current research constituted a pilot trial carried out in a controlled setting with no external validation in different educational settings or with larger populations. Future studies should take the form of a larger-scale implementation across several vocational institutions in Indonesia to confirm the preliminary results. In order to consider the app's sustained impact on student performance, motivation, and engagement over a substantial period, longitudinal research is recommended. Further research should examine the feasibility and cost-effectiveness of the mobile application once integrated into the existing vocational education curricula and infrastructures. Such extensive assessments would develop an informed perspective about the mobile application's capacity to holistically support vocational education in electrical installation.

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