Development of a Digital Based Laboratory at the Vocational School Center of Excellence (CoE)

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Abstract. Digital-based laboratories are innovations that aim to improve knowledge and practical skills in the laboratory without requiring assistance and free from time and place constraints. This study aims to develop a digital-based laboratory that is interactive, dynamic, animated, and attractive, and supported by user motivation to learn and understand productive electrical subjects. The components of this laboratory include augmented reality media, pre-tests, post-tests, assignments, tutorials, simulations, and laboratory materials. This research was conducted in the context of productive electrical subjects at the Center of Excellence (CoE) Vocational High School. The research method used is the Research and Development (R&D) method. Data analysis techniques include descriptive and inferential analysis that allows evaluation of the effectiveness of digital laboratories in improving students' cognitive and psychomotor competencies. Research instruments include knowledge tests, practical skills observation sheets, and questionnaires to measure user motivation and satisfaction. This digital-based laboratory is effective in improving student competencies, both in cognitive and psychomotor aspects. The digital-based laboratory developed in this study can be an effective and efficient tool to support practical learning in vocational schools, while overcoming time and place constraints.

Keywords: Centre of Excellence (CoE),Digital laboratory, Vocational School.

1 Introduction

Vocational education, especially Vocational High Schools (SMK), has a strategic role in preparing skilled workers who are ready to enter the industrial world. Along with the development of technology and the demands of industry 4.0, vocational schools are required to continue to improve the quality of education and training so that their graduates have competencies that are relevant to industry needs [1]. One effort to realize this is through the development of digital-based laboratories in vocational schools, especially in the SMK Center of Excellence (CoE) which is expected to be an example for other vocational schools[2].

The SMK Center of Excellence (CoE) is a flagship program of the Ministry of Education and Culture of the Republic of Indonesia which aims to improve the quality of vocational

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education in Indonesia[3]. This program is designed to produce vocational school graduates who have superior competencies and are ready to compete in the global job market. One important aspect in realizing the SMK CoE is the provision of modern learning facilities that are in accordance with the latest technological developments, including digital-based laboratories[4].In the context of the electrical power installation engineering department, especially for the subject of electric motor installation, the existence of a digital-based laboratory is very important[5]This is due to the increasingly rapid development of technology in the field of electricity and industrial automation, thus requiring students to have skills that are not only limited to conventional technical aspects, but also the ability to operate and understand digital-based systems[6].

However, based on the results of observations conducted at SMK SwastaSinar Husni 2 TR Labuhan Deli, which is one of the SMK CoE, it was found that there is still no digital-based laboratory for the electrical power installation engineering department, especially for the electric motor installation subject. This condition is certainly a challenge in itself in efforts to improve the quality of learning and prepare students to face the demands of the industry that is increasingly based on digital technology.The need for digital-based laboratories at SMK CoE, especially for the electrical power installation engineering department, is supported by various research and government policies.According to[7], The use of digital technology in vocational learning can increase the effectiveness and efficiency of the learning process, as well as help students understand complex concepts better. In addition,[8]emphasized that the integration of digital technology in vocational school laboratories can improve students' skills in facing the challenges of industry 4.0.

This digital-based laboratory is specifically designed to support learning in the subject of electric motor installation, with the main focus on the material of three-phase electric motor control. In this laboratory, students will learn and simulate various electric motor control circuits, including Direct On-Line (DOL), forward-reverse, and star-delta circuits. The use of this digital laboratory allows students to understand the working principles of these circuits in depth through interactive simulations and virtual experiments, which replicate real conditions in the field. This not only enriches the learning experience, but also increases students' readiness to face challenges in the industrial world[9].In addition, digital-based laboratories can also support the implementation of project-based learning (PBL) which is increasingly emphasized in the vocational school curriculum. According to[10]Project-based learning can enhance students' creativity, problem-solving skills, and collaboration skills. With digital-based laboratories, students can work on more complex projects that are relevant to industry needs.

The development of digital-based laboratories in SMK CoE is also in line with the Indonesian government's policy in improving the quality of vocational education. In Presidential Instruction Number 9 of 2016 concerning Revitalization of SMK, the government emphasized the importance of updating educational facilities and infrastructure in SMK, including laboratories, to be in accordance with the latest technological developments. Furthermore, Regulation of the Minister of Education and Culture Number 34 of 2018 concerning National Standards for SMK/MAK Education emphasizes that learning facilities and infrastructure in SMK must meet standards that are in accordance with industry needs. This strengthens the urgency of developing digital-based laboratories in SMK CoE, especially for the electrical installation engineering department.

The development of digital-based laboratories can also support the implementation of distance learning and blended learning which are increasingly relevant in the digital era. According to[11], Integration of digital technology in vocational learning can facilitate students' access to learning materials and practicums more flexibly, both in school and remotely. This is increasingly important given challenges such as the COVID-19 pandemic that require adaptation of learning models. In the context of electric motor installation subjects, digital-based laboratories can provide virtual simulators that allow students to do practicums online. This can complement physical practicums carried out in schools, thus providing a more comprehensive learning experience for students. In addition, the use of digital technology in laboratories can also facilitate more effective assessment and monitoring of student progress.

Based on the description above, it can be concluded that the development of a digital-based laboratory at the SMK Center of Excellence (CoE) for the electrical power installation engineering department, especially the electric motor installation subject, is an urgent need. This study aims to develop a digital-based laboratory model that is in accordance with the learning needs at SMK CoE, with a case study at SMKS Sinar Husni 2 TR Labuhan Deli. The results of this study are expected to provide a significant contribution to improving the quality of vocational education in Indonesia, especially in preparing SMK graduates who are ready to face the challenges of industry 4.0.

2 Method

This research adopts a research and development (R&D) approach by applying the 4-D model developed by Thiagarajan, Semmel, and Semmel in 1974[12]. This model was chosen because it offers systematic stages and is very suitable for the development of learning media, especially in the context of vocational education. The main focus of this research is to develop digital-based laboratory learning media for electric motor installation subjects, with a special emphasis on 3-phase electric motor control materials that include DOL (Direct On-Line), Forward-Reverse, and Star-Delta circuits.

This study follows the 4-D model that includes four main stages: Define, Design, Develop, and Disseminate. In the Define stage, the researcher conducts an analysis of needs, student characteristics, curriculum, and learning materials to understand needs and collect relevant information. The Design stage involves designing a prototype of digital-based laboratory learning media, including media format selection, interface design, storyboard creation, and evaluation instrument preparation.In the Develop stage, the designed prototype is refined into a mature product through expert validation and revision based on their input. Limited trials are conducted to obtain feedback from teachers and students. The final stage, Disseminate, involves the implementation of the product at SMKS Sinar Husni 2 TR Labuhan Deli as a SMK Center of Excellence (CoE).

This study used various data collection techniques such as observation, in-depth interviews, questionnaires, documentation, and tests to obtain comprehensive data. Data analysis was carried out using qualitative and quantitative approaches. Qualitative descriptive analysis was used for observation and interview data, while quantitative analysis was used for questionnaire and test data. The Likert scale was used to assess the feasibility of the product, and the paired

t-test was used to measure the effectiveness of the product in improving student learning outcomes. User responses were analyzed using percentage descriptive analysis.

3 Result and Discussion

3.1 Define

The definition stage is an initial step activity to collect data on learning needs that aims to determine and define requirements. Initial analysis activities are carried out through direct or open observation and interview activities to find out the problems faced during learning. Electric motor installation teachers were used as interview objects who stated that they only used the lecture method with the help of PowerPoint media, textbooks and Student Worksheets (LKPD) available in the library used to teach electric motor installation subjects. Based on the results of observations and interviews, especially for electric motor installation subjects on 3-phase motor control materials with DOL, forward-reverse and star delta circuits, it was found that there was no implementation of practical activities in the laboratory or using a digital laboratory in learning.

The results of observations of class XI students, researchers found obstacles, namely in the electric motor installation lesson, they had not carried out practicums in the laboratory due to lack of space and supporting equipment which caused students to feel bored and tired of following the electric motor installation lesson. Therefore, a special media format is needed that can encourage active involvement of students in learning and improve learning outcomes, namely using digital laboratory media in the form of the Simurelay application.

3.2. Design

This design planning stage has several stages to design the product being developed, namely media selection, format selection, and initial design of learning media. The media used to overcome the problems of limited laboratory facilities and infrastructure so that students can continue to carry out practicums is to use digital laboratory media in the form of the Simurelay application.

Fig. 1. Homepage

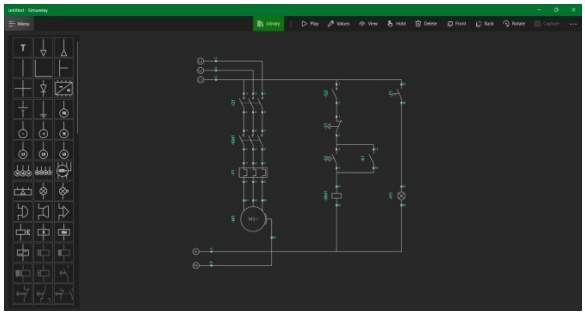

Fig. 2. Simurelay

The results of the media selection are that the researcher determines the learning media that is in accordance with the student analysis, concept analysis, and material analysis. The researcher uses teaching materials with the Simurelay application to help students improve their learning outcomes. The results of the initial design of the learning media are that the researcher designs learning media for electric motor installations developed using the Simurelay application in the form of a scope of 3-phase motor control material with DOL, forward-reverse and star delta circuits.

3.3. Develop

This stage is a continuation of the design stage that has been carried out previously. At this stage, the researcher conducted a validation test of the learning device by two validator experts and one electric motor installation teacher using an assessment instrument. If the validator's assessment shows several low categories, then a revision is made according to the advice of the validator expert. After the revision and declared good, the product test was immediately carried out on students. The following are the results of the expert assessment presented in Tables 1, 2, and 3.

Tabel 1. Subject Matter Expert

No	Aspect	Validator		Total Score	Average	Percentage (%)	Criteria
		1	2				
1	Content Suitability	51	48	99	8,9	99	Very Good
2	Presentation Suitability	45	44	89	9,8	89	Very Good
	Average Total Score				9,4	94	Very Good

Tabel 2. Media Expert

No	Aspect	Validator		Total Score	Average	Percentage (%)	Criteria
		1	2				
1	Information Guide	13	14	27	9	89,9	Very Good
2	Media Operations	49	40	84	8,9	89	Very Good
3	Media Systematics	14	13	27	9	89,9	Very Good
4	Media Aesthetics	20	15	35	8,8	87,5	Very Good
5	Design Principles	34	28	62	8,8	88,5	Very Good
	Average Total Score				8,9	88,96	Very Good

Tabel 3. Design Expert

No	Aspect	Validator 1	Validator 2	Total Score	Average	Percentage (%)	Criteria
1	Appropriateness of Design Use	30	24	54	9	90	Very Good
2	Attractiveness of Physical Appearance	25	20	45	9	90	Very Good
3	Suitability of Format	5	4	9	9	90	Very Good
4	Presentation with Target Characteristics	15	12	27	9	90	Very Good
5	Clarity of Material Presentation	15	12	27	9	90	Very Good
	Average Total Score				9	90	Very Good

The validation table of the trial results from experts shows that the digital-based laboratory media for electric motor installation material has a very high level of validity and is suitable for use in the learning process. Material experts gave an assessment of 94%, which is included in the very good category, confirming that the content of the material presented through this media is appropriate and supports learning objectives. Media experts gave an assessment of 88.96%, also in the very good category, indicating that the format and presentation of this media are appropriate and attractive to users. In addition, design experts gave an assessment of 90%, indicating that the design and layout of this media have been well designed, making it easier for students to understand and apply the material being studied. Overall, the results of this validation show that this digital-based laboratory media is valid, effective, and can be optimally integrated into electric motor installation learning activities in vocational schools.

After the digital-based laboratory media was validated and declared very good by experts, this media was then implemented in the learning process of electric motor installation. The application of this media was carried out with the aim of increasing the effectiveness of learning and facilitating students' understanding of the material being taught. Table 4 shows the results of students' opinions regarding the use of this media in learning.

Tabel 4. Student Opinion

No	Aspect	Average	Percentage (%)	Criteria
1	Information Guide	4.5	90	Very Good
2	Media Materials	4.6	92	Very Good
3	Evaluation	4	80	Very Good
4	Design and Facilities	4.3	85	Very Good
5	Pedagogical Effects	4.6	92	Very Good
	Average Total Score	4.4	88	Very Good

Students' opinions regarding the use of digital-based laboratory media showed very positive results, with a satisfaction percentage reaching 88%. This result is in the very good category, indicating that this media has succeeded in meeting students' needs in understanding electric motor installation material. This high level of satisfaction shows that the media used not only helps students in learning complex concepts, but also makes the learning process more interesting and interactive. Thus, this media has proven effective in increasing student understanding and involvement during the learning process.

3.4. Disseminate

In the final stage of the 4D development model, namely the Disseminate stage, researchers carry out activities to disseminate learning devices that have been developed during the research. This stage is a crucial step to ensure that the research product can be implemented widely and effectively in the context of education. In this case, learning devices in the form of digital-based laboratories using the Simurelay application are disseminated to schools, especially to teachers teaching electric motor installation subjects for class XI at the research location.This dissemination process does not only involve the physical delivery of learning products, but is also accompanied by a user guide and training for teachers so that they can optimally utilize this digital media in teaching and learning activities. The main objective of the Disseminate stage is to ensure that the digital laboratory learning products developed can be implemented well in schools, have a positive impact on the quality of learning, and are able to answer the challenges in teaching electric motor installation materials.

Furthermore, this dissemination also aims to obtain direct feedback from end users, namely teachers and students. This feedback is very important to assess the effectiveness of learning media in real situations and to identify areas that may require further improvement. Thus, this learning product can continue to be refined and adapted according to field needs, ensuring that this Simurelay-based digital laboratory media can be an effective and innovative tool in improving students' understanding of electric motor installation concepts. Ultimately, this dissemination is expected to not only enrich the learning process, but also contribute to the development of more modern and technology-oriented education.

4. Discussion

This research focuses on the development and implementation of digital-based laboratory media using the Simurelay application in learning electric motor installation in vocational high schools. This research has strong relevance to global trends in vocational education, where the use of digital technology is increasingly recognized as an effective tool to improve the quality and efficiency of learning. The use of digital-based laboratories in learning electric motor installation is designed to address several major challenges in engineering education, such as limited access to physical equipment, high costs, and the need for a safe and controlled learning environment.In the context of engineering education, digital simulations such as those offered by Simurelay allow students to learn through practical experience without the risks associated with real electrical equipment. This is in line with previous studies showing that simulation-based learning can improve students' understanding of complex technical concepts and enhance their skills in applying that knowledge to real-world situations[13]. This study adds further empirical evidence that the use of simulation in engineering learning is not only effective, but can also be widely implemented across educational institutions.

Media validation by experts in this study strengthens the superiority of Simurelay as a platform capable of supporting interactive and high-quality learning. Material experts gave a score of 94%, indicating that the content presented in this media is in accordance with the curriculum and supports the achievement of student competencies. Media experts gave a score of 88.96%, indicating that the appearance and format of this media are quite attractive and easy for students to use. Meanwhile, design experts gave a score of 90%, confirming that the

user interface and overall design of this media have been well designed to facilitate learning.Furthermore, the opinions of students who reached a satisfaction level of 88% strengthen the findings that this media is not only well received, but also effective in helping them understand the material of electric motor installation. This is in accordance with previous research which states that student engagement tends to increase when they use interactive and visual learning media, such as digital simulations[14]. Simurelay, with its ability to simulate real-world scenarios in a safe environment, gives students the opportunity to test and reinforce their understanding through controlled trial and error.

The 4D model used in this study also has important implications. The distribution of learning devices to schools and training for teachers demonstrates a commitment to ensuring that these innovations can be practically implemented in everyday teaching. This study seeks not only to develop innovative learning products, but also to ensure that these products can be adopted and utilized by teachers in real educational contexts. This is in line with the findings of[15]which states that effective implementation of educational technology requires support and training for educators to achieve optimal results.Overall, this study highlights the importance of innovation in engineering education, especially in utilizing digital technology to address existing challenges. The digital laboratory media based on Simurelay developed and implemented in this study shows great potential in improving the quality of learning in vocational schools, especially in the subject of electric motor installation. With excellent validation results from experts and positive feedback from students, this study provides a strong foundation for wider use of this technology in other schools. In addition, this study also paves the way for further development in the use of digital simulation for other fields of study, which can ultimately improve the effectiveness of vocational education worldwide.

5. Conclusion

This study emphasizes the importance of innovation in the development of digital-based learning media, especially in the context of learning electric motor installation in vocational schools. This study aims to develop, test, and disseminate digital laboratory media based on the Simurelay application designed to improve effectiveness and efficiency in the teaching and learning process. The results of the study indicate that this media has been very well validated by experts in the fields of materials, media, and design, each of which gave high ratings, with results of 94%, 88.96%, and 90%. This validation indicates that this media is feasible to use and has great potential to support more interactive and interesting learning.

After validation, this media was implemented in a real learning process, where students gave positive feedback with a satisfaction level reaching 88%. This shows that this digital laboratory media not only helps students understand the material being taught, but also increases their involvement in the learning process. This success confirms that the use of digital technology in education, especially in the fields of engineering and vocational, can have a significant positive impact on student learning outcomes. The developed learning devices are distributed to schools, especially to teachers teaching electric motor installation for class XI. The distribution process involves training and usage guides aimed at ensuring that teachers can implement these media optimally. This is important to ensure that the benefits of

these learning media can be widely felt by students, while also providing opportunities for teachers to improve their teaching methods with more modern and effective tools.

This research has succeeded in achieving its main objective, which is to develop a valid, effective, and usable digital laboratory learning product in teaching electric motor installation. The use of Simurelay as a platform in this media has proven to be helpful in presenting complex materials in a way that is easier for students to understand and apply. In addition, the dissemination process carried out also shows that this media can be well adopted in schools, opening up opportunities for wider implementation in various other educational institutions. Digital laboratory media is a significant innovation in engineering and vocational education. This media not only improves the quality of learning, but also has the potential to be a model that can be replicated and further developed for other fields of study. Thus, this research makes a real contribution to the development of education that is more adaptive to technological developments, which will ultimately help students prepare themselves to face challenges in an increasingly complex and technology-based world of work.

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