Virtual Laboratory for Educational Institutions

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Abstract. This research aims to develop a Virtual laboratory model to support basic vocational education practicums, both through Virtual laboratory applications and practicum content in the form of virtual practicum modules. The research employed a development method. The feasibility of the Virtual laboratory was tested using a feasibility test instrument based on expert justification, while the model acceptability and effectiveness were assessed using field tests through quasi-experiments. The feasibility test results showed an average total score of 85.69, compared to scores of 85.52 for the Administrator group, 83.96 for the Teacher and Instructor group, and 87.59 for the student group. Meanwhile, the effectiveness of the Virtual laboratory system reached an index of 88.84, which is considered very high. The research findings are useful as a practical solution for vocational schools with limited basic laboratory facilities as a solution to improve graduate competency according to stakeholder standards.

Keywords: virtual, laboratory, practicum, vocational, education

1 Introduction

Technology is developing rapidly in line with scientific advances and societal demands. The workplace, as a user of educational institution graduates, always demands standard competencies to meet workforce needs. Likewise, the demand for middle-level workers produced by vocational high schools is generally below stakeholder standards. Numerous studies have revealed the low competency outcomes of vocational high school graduates, leading to low absorption in the workforce [1]. This weakness will impact the low competency, leading to graduate failure in the workforce [2]. This has been found through several studies, such as Ohagwu et al. [3], and other studies that have successfully revealed the low quality of graduates due to students' weak mastery of basic skills competencies [4].

The quality of graduates is reflected in the competencies they achieve as a result of their learning. This quality is determined by many factors, such as teaching materials, learning media, and the systems used [2,5]. Initial studies have shown many limitations related to the lack of practical facilities to support the educational process. These weaknesses are caused, among other things, by a lack of practical time and limited materials and equipment. Likewise, Vocational High Schools in Medan, Indonesia, have a problem with weak laboratory practicums, resulting in low graduate competency. Several studies have successfully revealed that student learning outcomes are very low compared to stakeholder standards [6]. This weakness results in low quality, making it difficult to get a job [3]. The main cause of the low

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quality of practical learning, especially laboratory practice, is the lack of laboratory equipment [7,8]. Remedial learning efforts and field and industrial practices have been carried out, but have not been able to overcome the existing problem [9]. Therefore, innovative and appropriate efforts are needed to overcome the problem of low student competency.

The limitations of laboratory practicums must be addressed so that student competencies do not decline further. Research focuses on Virtual laboratory practicums to improve basic competencies, while expertise competencies must be achieved through real practicums. The research problem is stated in four aspects, namely: (1) The right practicum model to overcome the limitations of laboratory facilities; (2) The right content for Virtual laboratory practicums; (3) The effective laboratory practicum model to improve learning outcome competencies. The right approach is to develop a Virtual laboratory practicum model [10]. This model has the advantage of efficiency in organizing practicums without being hindered by place, time and cost. Another advantage is virtual visualization so that students more easily accept practicum materials, can be repeated without being hindered by time, place and equipment and cost [10,11]. Virtual laboratory can visualize abstract things into concrete ones so that they are easy to understand [8,12,13], and not only for theoretical learning but also for laboratory practicums [14]. Virtual laboratory have been widely developed, but this Virtual laboratory was built with several unique features, namely including virtual reality content for concrete events, and augmented reality for abstract events in the form of animations and simulations [12,14].

This research aims to develop a virtual laboratory model as a tool for remedial learning through virtual laboratory simulations. A virtual laboratory is a laboratory model consisting of interactive multimedia-based computer software that can simulate laboratory practices as if the user were in a real laboratory [11]. V-Labs can also simulate real-life lab activities using computer simulation programs in the laboratory [12]. Besides the high cost of equipment, high-risk and dangerous experiments are more appropriately simulated in virtual form [15]. Thus, V-Labs is a web-based learning tool that allows students to carry out learning activities independently through virtual laboratory simulations.

Essentially, virtual learning using virtual laboratory is not significantly different from real-life labs; in certain circumstances, learning using virtual laboratory is even more effective [16]. Furthermore, learning using virtual laboratory can also improve creative thinking skills, train problem-solving skills, increase learning motivation, and promote meaningful learning [16,17]. Several studies have shown that virtual practicums are more effective for electrical and electronics [6], mechatronics [8], and physics [9,10] than real-life practicums. With these advantages, this research is considered urgent in efforts to improve student learning outcomes, especially practicum competencies for areas of expertise. Implementing virtual laboratory practicums is a solution that is considered appropriate for vocational high schools that do not have complete laboratory facilities.

2 Research Method

This research was conducted at the Faculty of Engineering, Medan State University, with SMK Muhammadiyah 4 Medan as the experimental site partner. The application program design used the System Development Life Cycle method [19]. This model is widely used in information system development, including web-based systems. This model has many advantages, including its complete lifecycle, making it very helpful for developers to identify user needs that must be accommodated in the application software being developed. The first step in system investigation consists of two activities: a preliminary study and a feasibility study to define the problem, design alternative solutions, system development, and operational, technical, economic, and time feasibility. System analysis begins with an analysis of the current system and determines the requirements for the new system, a procedure for converting logical specifications into a design model. System design formulates features, structures, software development, display criteria, configuration, and system approval. System implementation includes system integration, system testing, and the transition to the new system.

Virtual laboratory performance analysis and testing follow life cycle procedures that verify the program meets system requirements [19]. System testing is performed using stub testing and unit testing. Next, Black Box Testing and White Box Testing are carried out and concluded with Integration Testing to test the interaction between modules to ensure the flow of information between processes is running correctly [20]. The virtual laboratory aapplication feasibility test uses instruments that refer to the standard feasibility indicators [21]. With these two tests, the level of feasibility and effectiveness in supporting virtual laboratory practicums conducted online will be obtained.

3 Results and Discussion

The development of web learning for virtual laboratory used the SDLC model [19]. The stages involved are as follows.

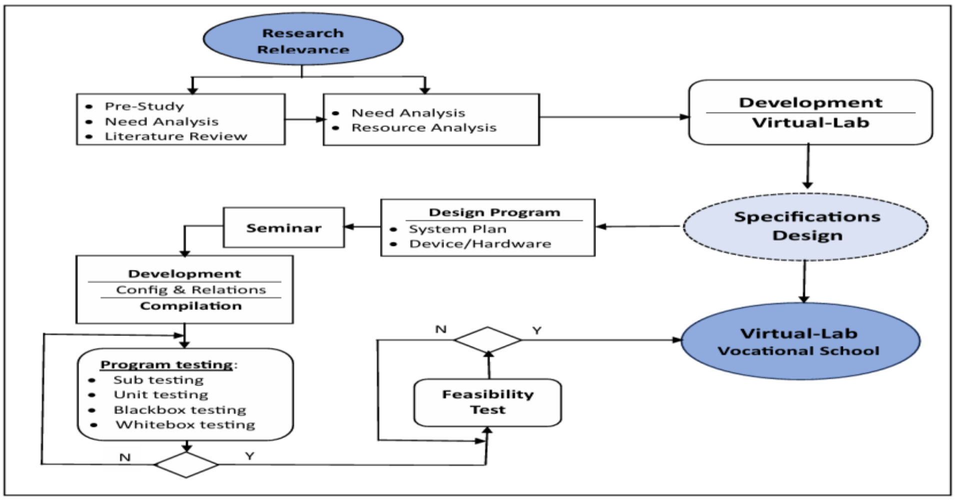

Fig.1. Flowchart of research

The initial stage consists of two main activities, namely preliminary studies and feasibility studies. The initial study includes (1) identifying problems, (2) explaining the current system procedures, (3) compiling alternative solutions to solve the problems faced, (4) classifying system development, and (5) evaluating the current system. Meanwhile, the feasibility study is concerned with analyzing problems according to the final objective, including (1) operational feasibility of the system, (2) feasibility from a technical aspect, (3) feasibility from an economic aspect, and (4) time feasibility. The second stage, System Analysis, is the stage of studying the current system and evaluating initial data to determine system requirements and maximize resources, designing a new system by determining conversion procedures to be more effective and efficient, easy (friendly) and logical. In the third stage, namely System Design to compile logical specification conversion procedures (1) conducting evaluations and formulating system services in more detail, evaluating alternatives for system configuration, configuration, and preparing a new system. The fourth stage, namely System Implementation, regulates procedures for completing the system design, testing and installing new programs, conducting system trials and compilation as a final decision. The Virtual-Lab application is shown in **Figure 2.**

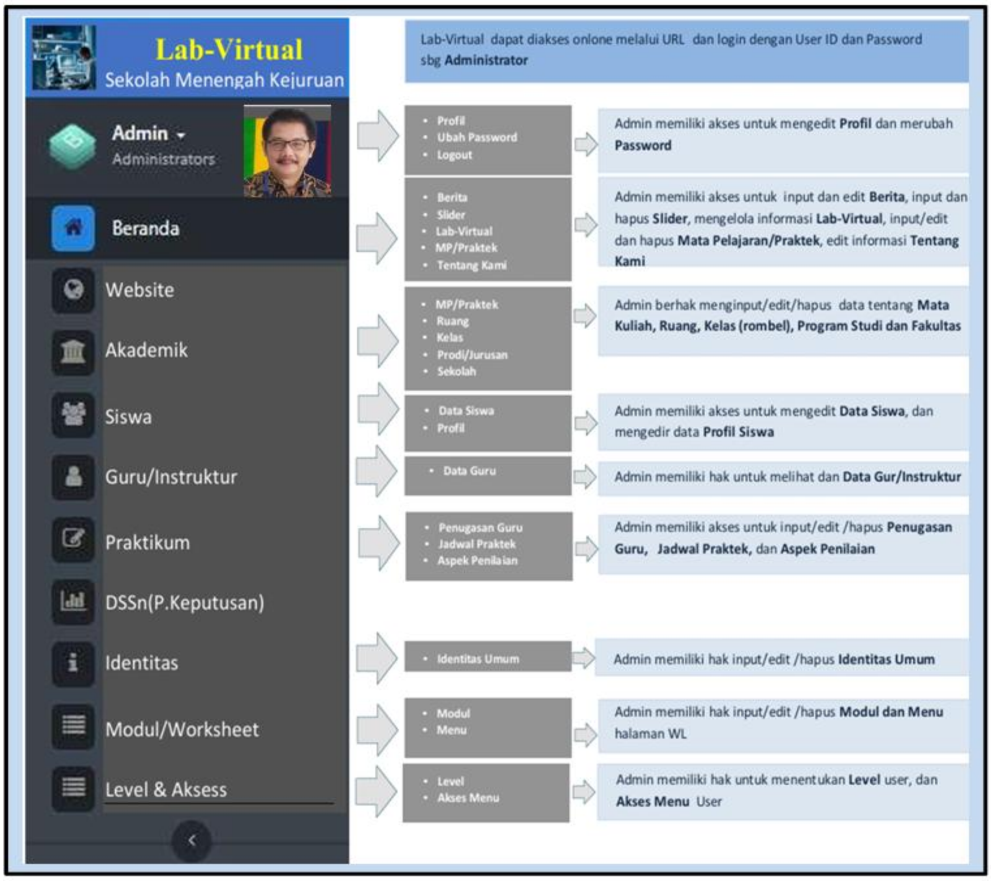

Fig.2. Configuration of Virtual-Lab application

Login as an administrator provides several features: (a) Academic, a menu for managing subject data, rooms, study programs or majors, and academic years; (b) Student, which manages active students; (c) Teacher, which manages subject instructors and scheduling. Access as a Teacher provides several features: (a) Student approval and academic data; (b) Learning management; (c) Assessment and reporting. Logging in as a Student provides access to (a) Practical learning registration; (b) Downloading digital and virtual teaching materials; and (c) Exams.

The virtual laboratory application is tested for feasibility using a feasibility test instrument [21]. Program feasibility testing is conducted on each unit or user group to determine whether the system's performance meets the design. The testing process executes the software to determine whether the system meets specifications and operates within the desired environment. A summary of the program performance test results is shown in the following **Table 1**.

Table 1. Feasibility test of virtual-lab system

No	Unit of Testing	Mean Score of Feasibility			
		Admin	Teacher/ Instructors	Students	Total
1	Design	86.47	83.62	88.74	86.28
2	OS/Software support	92.58	95.36	95.59	93.97
3	User needs	88.73	82.92v	91.58	87.74
4	Compatibility	78.56	76.85	80.52	78.64
5	Reliability	79.65	79.89	92.48	84.01
6	Security system	84.18	85.68	88.56	86.14
7	Ease of used/Friendly	88.46	83.38	83.64	85.16
	Total Mean Score	85.52	83.96	87.59	85.69

Test results show that the feasibility of the virtual laboratory program is relatively similar across user groups. The program's design received a mean score of 86.28; OS/software support received a very high score with a feasibility of 93.97; user needs met with a score of 87.74; system compatibility with a score of 78.64; application reliability with a score of 84.01; system security with a feasibility of 86.14; and ease of use with a system friendliness with a score of 85.16. Overall, the virtual Laboratory model received a feasibility index of 85.69, which can be classified as very high.

When analyzed by user group, the seven feasibility indicators yielded a mean score of 85.52 for the Administrator group, 83.96 for the Teacher/Instructor group, and 87.59 for the Student group. This demonstrates that all three user groups achieved what they needed in utilizing the virtual laboratory application to support virtual laboratory practical learning. This makes the virtual application highly desirable and capable of meeting user needs with an efficacy rate of over 85%. There were no significant obstacles or weaknesses in the virtual laboratory application, which was developed to support the efficiency and effectiveness of laboratory practicums. Furthermore, the effectiveness of the virtual laboratory model is shown in **Table 2**.

Table 2. Summary of practical effectiveness scores baed on students group

Group	Q.Pract	L.OComes	Motivation	Flexibility	Time Eff.	Eff.Cost	Total
Reguler	65,34	72,83	64,82	54,74	72,65	64,85	65,87
Virtual	85,57	83,62	86,72	95,85	90,68	90,62	88,84

The results of further analysis stated that the effectiveness of the virtual laboratory system based on two user groups, namely an average of 65.87 was obtained for the regular practicum student group, while for the virtual practicum student group, the effectiveness was very high, namely 88.84. The high effectiveness of the system for students participating in virtual practicums was dominated by time efficiency and cost efficiency in implementing practicums. With virtual laboratory practicums being much more efficient than regular practicums. Likewise, the flexibility aspect had a very high deviation, namely 54.74 in the regular practicum student group and 95.85 in the virtual practicum student group. The distribution of data with the interpretation of each aspect of system effectiveness is shown in **Figure 3**.

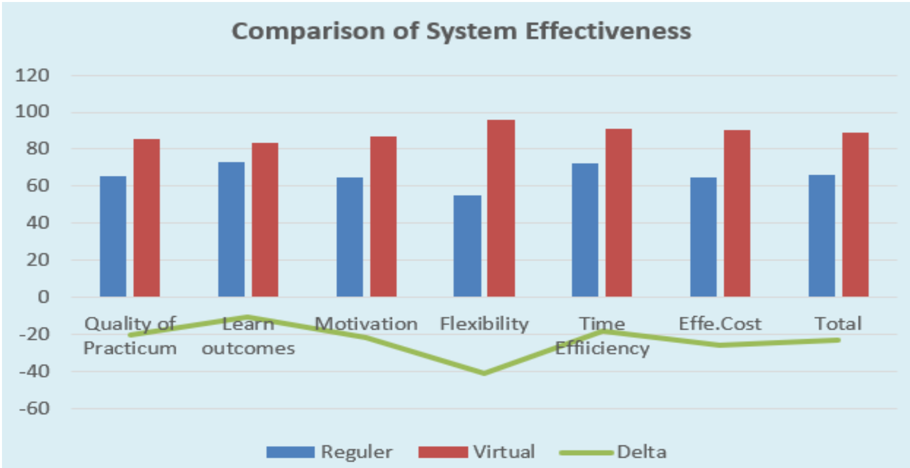

Fig.3. Comparison of system effectiveness based on user group

The comparison of the effectiveness of the laboratory practicum system showed a significant deviation between the regular and virtual practicum groups. In all aspects, scores generally ranged from 54 to 72.85 in the regular practicum group, with a mean score of 65.87. Meanwhile, in the virtual practicum group, the mean score was 88.84, with all aspects of system effectiveness achieving very high scores, ranging from 83.62 to 95.85. This fact is undeniable, indicating that the use of the virtual laboratory system is highly needed and appropriate for vocational high school students and can even improve the competency of practicum learning outcomes, as well as significantly improve time and cost efficiency.

The results of this study reinforce the results of relevant research that has been conducted. It is undeniable that the use of virtual laboratories has been proven to improve competency in learning outcomes, as previously demonstrated by previous researchers [4,10,11]. Another advantage of virtual laboratories is its effectiveness, which showed a significant deviation between the regular and virtual practicum groups. The findings of this study are consistent with previous research [15,16,17]. This study also has the advantage of revealing a significantly higher growth in students' psychological aspects when conducting virtual laboratory practicums compared to regular practicums. Therefore, this study has proven capable of addressing the problem of the weaknesses of laboratory practicums in schools that do not have complete laboratory equipment. The use of the virtual laboratory application system is a solution to increase the effectiveness of practicums, namely increasing the competence of learning outcomes while significantly increasing motivation and time and cost efficiency.

4 Conclusion

Virtual laboratory was developed to address the problem of low student learning outcomes due to limited laboratory equipment. By analyzing user needs, the virtual laboratory application was able to address user needs for conducting virtual laboratory practices. Feasibility tests demonstrated that the virtual model had a high level of feasibility, with a mean score of 85.69. Furthermore, student learning motivation also increased significantly. The virtual laboratory model also increased the effectiveness of practicums, increasing time efficiency and flexibility in virtual laboratory activities, unconstrained by time, space, equipment, and administrative constraints, unlike regular laboratory practices. Therefore, the results of this study proved effective in addressing the challenges faced, and the output of this research represents an innovation that provides an appropriate solution to address these issues, thereby improving the quality of education.

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