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Students' Expectations from Using Virtual Laboratory Media in the Electronic Engineering Education

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Abstract:
Virtual laboratories are useful for Electronic Engineering Education students in practical learning. Virtual laboratories provide real-world experience for students from the virtual world to the real world, making practical work on complex equipment easy. This study aimed to find out the perceptions and activities of students towards Android-based virtual laboratory applications as an introductory learning medium for practice in industrial electronics courses. The method used in this research is Research and Development, which is used to design a Virtual Laboratory. This study, based on the results of a survey of Electronic Engineering students on the use of virtual laboratory media, shows a positive response, although some students do not subscribe to the internet at home. The data shows that 95% of students responded strongly agree and agree. Therefore, an Android-based virtual laboratory in the Industrial Electronics course is feasible in practical learning. The implication is that a virtual laboratory makes it easier for students to do practicum during the COVID-19 pandemic. Virtual laboratories can improve student skills in the field of industrial electronics. They help in independent learning because they can be operated anytime and from anywhere. The novelty of this research is a virtual laboratory project in the electronics industry.

Keywords: virtual laboratory, learning, industrial electronics.

学生对在电子工程教育中使用虚拟实验室媒体的期望

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摘要：
虚拟实验室对电子工程教育学生的实践学习很有用。虚拟实验室为学生提供从虚拟世界到现实世界的真实体验，让复杂设备的实际工作变得轻松。本研究旨在了解学生对基于安卓的虚拟实验室应用程序作为工业电子课程实践的介绍性学习媒介的看法和活动。本研究使用的方法是研发，用于设计虚拟实验室。这项研究基于对电子工程专业学生使用虚拟实验室媒体的调查结果，显示出积极的反应，尽管一些学生在家中不订阅互联网。数据显示，95%的学生反应强烈同意并同意。因此，工业电子课程中基于安卓的虚拟实验室在实际学习中是可行的。这意味着虚拟实验室使学生在新冠肺炎大流行期间更容易进行实习。虚拟实验室可以提高学生在工业电子领域的技能。它们有助于独立学习，因为它们可以随时随地操作。这项研究的新颖之处在于电子行业的一个虚拟实验室项目。

关键词：虚拟实验室、学习、工业电子。

1. Introduction

At the beginning of 2020, the world was hit by the COVID-19 pandemic caused by the coronavirus. The impact caused by the virus was so extraordinary that it paralyzed the world economy. The world of Education has also been affected by the COVID-19 pandemic. Before the COVID-19 pandemic, learning activities could be carried out in the school environment face-to-face in the classroom. However, at this time, the learning process is carried out online through internet media. This is done so that the learning process continues and succeeds as expected. Learning online has many complaints from educators, lecturers, and students. The electronic engineering study program students at the State University of Jakarta (UNJ) are no exception. Lecturers are required to continue to carry out lectures even though they are online. Because there is no preparation for online learning, lecturers must have strategies and design so that learning activities remain interesting and not monotonous to their students. The learning process is designed in such a way as to create effective and efficient learning. Likewise, although the learning process in practical courses is carried out from each student's home, they can still practice independently with the media that can facilitate the learning process. Consideration of gender differences and differences between education levels from elementary school to college, in addition to the readiness of students to participate in the online learning process during the pandemic, the readiness of technology used as self-efficacy in online learning also determines student learning outcomes during the pandemic (Tang et al., 2021). During the COVID-19 pandemic, digital support strategies are better for meeting all student needs; this support can be in the form of involvement and support for linkages to be very important between students and students and students with teachers (Chiu, 2022). Learning in the network (online) is the best solution and solution for the world of education in learning activities as the fulfillment of students to get learning. A survey conducted on 672 institutions with 897 lecturers in America showed that almost all institutions switched to an emergency teaching and learning approach with an average of no online teaching experience. By changing the form of assignments and exams during online learning, online digital material support is very helpful for students in completing assignments and exams from home (Johnson et al., 2020).

In the electronics study program, Faculty of Engineering, State University of Jakarta, there is an industrial electronics course which is one of the expertise courses that students of the electronics study program must take. In this course, students must master the theory and have practical skills. The Electronic Engineering Education Study Program, Faculty of Engineering, UNJ prepares its graduates to become teachers in vocational high schools (SMK) and work in industry. With these demands, graduates of electronic engineering education are ready to enter the world of work. An educational process is needed that can equip students with theory and practice. In the electronics study program, several courses contain theory and practice. One of the courses containing theory and practice is the industrial electronics course, usually abbreviated as ELIN. When students take ELIN courses, they are familiarized with the theories of SCR, DIAC, TRIAC, etc. In addition to these theories to provide mastery of skills, students are taught about practicum. In practice, students are given to measure components, assemble a circuit as control and do a project. With mastery of practice, it is necessary to have suitable materials, measuring tools, and adequate practice equipment. Ideally, each Student can practice individually with the necessary equipment and components.

However, if the amount of equipment does not match the number of students, a solution must be found to continue mastering the skills. Another concern is that if the amount of practice equipment is not proportional to the number of students, there will be errors in using measuring instruments in practice. These errors can be due to using a scale to measure current, voltage, and others that are not mastered, can also not master how to

read, and finally do not understand how to use measuring instruments. One solution to minimize errors in assembling industrial electronics circuits and measuring errors in industrial electronics circuit practice can be overcome with learning media specifically designed for the practice of Industrial Electronics courses. The media in question is a virtual laboratory. Before practice, students can watch videos on assembling ELIN practices and simulate with virtual laboratories. Why is virtual laboratory media needed before students practice? According to Shapiro (2003), media can change individual perceptions by showing a changed point of view that may fundamentally challenge the viewer's initial reaction to a character, group, or situation. Based on Shapiro's (2003) statement that the media has a changing effect on individual perceptions from different points of view, it is necessary to use media, especially in practical learning.

According to Asmiyunda et al. (2018), it is important to design a readable website by choosing the best line length, line height, font style, font size, and combination of font background colors. Virtual laboratories provide practical experiences provided in real-life simulations. Students are familiarized with real-world electronic equipment, which has simple equipment and components to resemble a real laboratory environment and is effective for engineering students to study (McCusker et al., 2018).

Suppose we pay attention to doing the usual practice, some quite time-consuming preparations, first 1) prepare the job sheet, 2) prepare the necessary equipment according to the job sheet, 3) provide brief directions, 4) carry out practice and measurements, 5) record the measurement results, and 6) make a temporary report. With virtual labs, Steps 1 to 3 can be shortened because students can learn them before entering the practice room and can even be studied at home, in vehicles, and anywhere. In addition to what was stated above, students who practice without virtual lab media/ may have large measurement and assembly errors, so the safety of components and equipment is threatened. With virtual laboratories, this can be minimized because students have seen videos that will be assembled and circuit simulations with games through virtual laboratories. With virtual laboratory media, students can learn what will be practiced anywhere, anytime, without being limited by space, time, and distance.

Research in utilizing virtual laboratory media in the learning process has been carried out to improve student learning outcomes. The research conducted by Nassef et al. (2020) shows that virtual laboratories can introduce education and training skills in learning activities. So it can measure electrical signals accurately and manipulate synchronized data efficiently. Subsequent research was carried out with experiments by Ghergulescu et al. (2019). Experimental data showed that student results were greatly helped by using virtual laboratories in conceptual understanding of electronic circuits, DoCircuits on circuit design, and engineering analysis skills for second-year students of the Electronics program. Telecommunications improve their circuit design and analysis skills due to virtual laboratories' wide range of capabilities. Engineering students can also use Kuczmann and Budai's (2019) research on that virtual laboratory to design placement-based control poles for typical control problems: inverted pendulum, Furuta pendulum, crane, ball, and beam. So, controller performance can be studied on real-life application models. Mathematical models and design controllers are presented and experienced in the virtual engineering control laboratory.

Virtual laboratories are used as learning media that by design can be applied to various kinds of technology products, one of which is smartphones. The Game-Based Learning (GBL) mobile application is built according to age and education level development and adapted to curriculum developments and the demands of science and technology. Virtual laboratories as learning media can be developed and utilized according to the lecture design. Virtual laboratories allow creating a new, effective, and fun learning atmosphere to achieve learning goals.

2. Methods

This research uses a survey method based on the cross-sectional survey design questionnaire described by Matthews and Ross (2010), Gay et al. (2009), Creswell (2012), Bryman (2012). This method is intended for researchers who only need to collect data at one point in time. This cross-sectional design effectively collected the data from people's current opinions and responses (when the survey was conducted). Robson and McCartan (2016) explain that the survey method is a fixed design first planned and implemented.

This study aims to find out the opinions and responses of Electrical Engineering students at the State University of Jakarta in using Android-based virtual laboratory media for practical activities for Industrial Electronics courses during the learning process. The subjects of this study were students of Electrical Engineering semester 3 with a total of 40. Before taking this Industrial Electronics course, students were required to study Basic Electronics 1 and 2.

The questionnaire developed in this study consisted of 36 statements that had to be filled out by respondents or students regarding the use of virtual laboratory media in the experimental learning process of Industrial Electronics courses. Out of 37 respondents, only 33 respondents returned. Questionnaires were distributed via Google form by filling in the bits provided by the researcher to determine the success of this virtual laboratory media in improving student understanding and learning outcomes for practical courses in Industrial Electronics.

3. Results and Discussion

The data were obtained by questionnaires to 33 students. Almost 95% stated that the tendency was to agree strongly and agree with the existence of a virtual laboratory for practical learning.

Table 1. The students' replies

No.	Statement	1	2	3	4
1.	Android-based virtual learning media for practical introduction to industrial electronics courses is less attractive	12.2	72.73	9.09	6.06
2.	I prefer to study industrial electronics material through Android-based virtual media rather than other lecture materials.	12	70	15	3
3.	Even though the industrial electronics course material is quite difficult, I still enjoy learning it.	0	9.1	85	3
4.	The convenience of studying industrial electronics course material through Android-based virtual media is due to learning independence.	0	24	64	12
5.	I studied industrial electronics courses through this Android-based virtual media because of my desire.	3	45	48	3
6.	A student's task in studying industrial electronics through Android-based virtual media is unclear compared to other tasks.	15	82	3	0
7.	I would not say I like learning through Android-based virtual media because it is difficult for me.	15	85	0	0
8.	I enjoy learning through Android-based virtual media because the lecturers do not notice it	9.1	55	33	3
9.	If there is a task related to industrial electronics without being asked, I will do it through Android-based virtual learning media.	3	52	42	3
10.	With the Android-based virtual learning media, I do not have to be responsible for my tasks.	27	67	3	3
11.	I feel proud of the existence of Android-based virtual learning media because, with them, students can learn well.	3	211	67	9.2
12.	Learning with Android-based visual learning media is not tied to time	0	9.1	70	21
13.	I am happy with the existence of Android-based virtual learning media because I am required to continue learning with them.	0	55	42	3
14.	I am proud of Android-based virtual learning media because I must learn new materials.	0	30	67	3
15.	What makes me not like learning through Android-based virtual learning media is that I always have to access the internet to do my assignments.	0	48	30	21
16.	I like learning through Android-based virtual learning media because it does not require an organization to learn.	3	42	52	3
17.	I am happy and proud to learn through Android-based virtual learning media because lecturers do not supervise it	12	42	39	6.1
18.	I am happy to choose Android-based virtual learning media because, with them, I do not need to ask many lecturers	9.1	55	36	0
19.	I enjoy learning with Android-based virtual learning media because I do not bother looking for reading sources, studying the material.	6.1	9.1	76	9.1
20.	Doing tasks through Android-based virtual learning media is very easy, so students do not need any organization.	6.1	64	27	3
21.	With Android-based virtual learning media, I cannot choose the material to be studied.	3	61	18	18
22.	Learning resources in Android-based virtual learning media are very cheap.	3	6.1	82	9.1
23.	I do not need basic knowledge in doing tasks through Android-based virtual learning media	12	76	0	23
24.	Learning through Android-based virtual learning media does not require high costs	3	21	67	9.1
25.	The Android-based virtual learning media that I use for learning is easy. Therefore I like Android-based virtual learning media	0	15	79	6.1
26.	Android-based virtual learning media software for industrial electronics courses is not widely found in the market.	0	15	82	3
27.	With Android-based virtual learning media, understanding the content	0	45	52	3

	of industrial electronics courses does not require sophisticated software.				
28.	For learning with Android-based virtual learning media, it is not necessary to socialize	27	64	9.1	0
29.	Studying industrial electronics course material in this Android-based virtual learning media is very boring/ because the presentation of the material is monotonous.	3	73	24	0
30.	This Android-based virtual learning media does not help much in the progress of the electronics learning industry for me	6.1	85	9.1	0
31.	If there a material that is difficult to understand in this Android-based virtual learning media, I always discuss/ask my other friends in understanding the material	0	15	67	15
32.	In studying industrial electronics course material through Android-based virtual learning media, if the material is incomplete, I look for material in existing sources.	0	6.1	48	45
33.	Android-based virtual learning media does not determine student intelligence, so students do not need to have an understanding of Android-based virtual learning media	12	67	18	3
34.	A student always chooses an easy way/strategy to learn something in his studies, so this Android-based virtual learning media is very helpful	0	9.1	76	15
35.	In this virtual learning media, the strategies used have been adapted to technological advances	0	6.1	70	24
36.	For a student, it does not depend on Android-based virtual learning media	3	21	65	15

The above instrument data for easy reading can be seen in the histogram below.

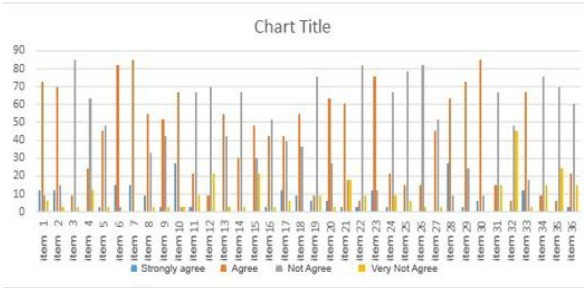


Figure 1. The survey results

So it is clear that most of the students' attitudes strongly agree and agree with seeing virtual laboratory before practice. From the results of the semi-open questionnaire, it can be seen that from 33 students, only nine people who subscribe to the internet at home use the provider while the remaining 29 do not subscribe to the internet.

Table 2. Those who subscribe to the internet in megabits per second

	Provider	Many	Megabit
1	Speedy Dari Telkom	2	➢ 5
2	Indihom	5	
3	First Media	2	
4	MNC PLAY 1	1	

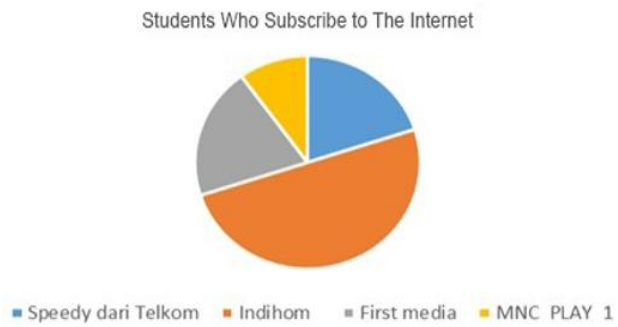


Figure 2. Those who subscribe to the internet in megabits per second

Table 3. Internet access

	Tools used	Many	Mega
1	Computer	-	
2	Tablet/iPad	-	
3	Handphone 33	33	
4	Laptop 5	5	
5	Others mention Cable TV	2	

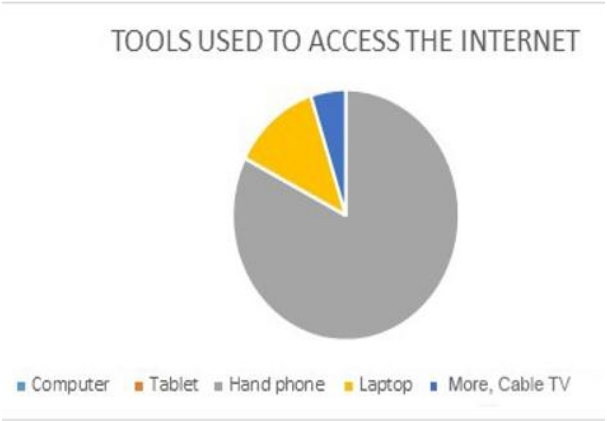
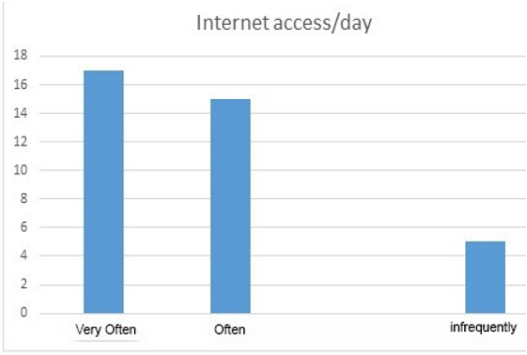


Figure 3. Internet access

Table 4. How often to access the internet?

	Tools used	Within one day	Mega
1	Very often	> 17	
2	Often	15	
3	Rarely	-	
4	Very rarely	5	



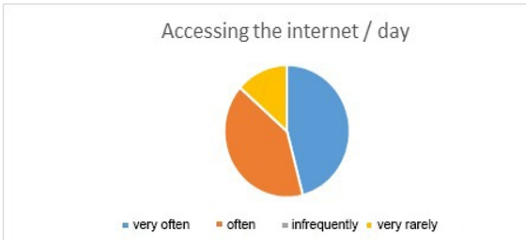


Figure 4. How often to access the internet?

Table 5. Where to access the internet?

	Where to access the internet?	Respondents
1	At home	24
2	Campus	6
3	Internet cafes	-
4	Cafe	-
5	Another place	3

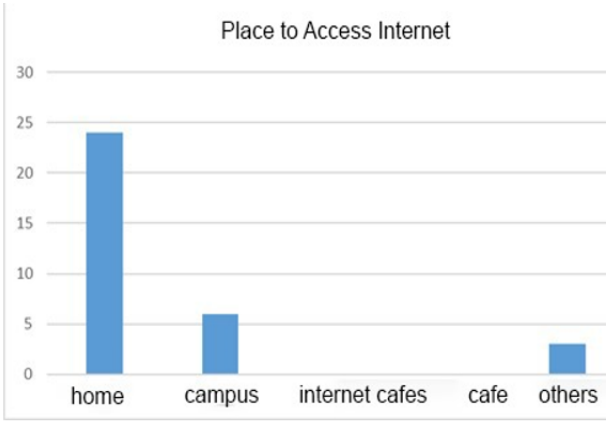


Figure 5. Where to access the internet?

The survey questions with answer options:

1.Does your school have a computer laboratory?

a. Yes

b. Not

2. If there is a computer laboratory, is there easy internet access?

a. Yes

b. Not

3. Are the computers in your school used for online learning?

a. Yes

b. Not

The virtual laboratory media used by students in this study was used to solve problems in the Industrial Electronics practical course in assembling circuits and measuring Industrial Electronics circuits. By using virtual laboratory media, students can easily simulate assembling Industrial Electronics circuits and measuring Industrial Electronics circuits. The virtual media laboratory provides a hands-on learning experience for students without using real and complicated equipment. Learning using virtual laboratory media provides a good starting point for collaboration and participation between students and other students and students and lecturers. The use of virtual laboratory media can be done by students anywhere and anytime, making it easier for them to learn to improve their abilities in assembling Basic Electronics circuits and measuring Industrial Electronics circuits.

The use of virtual laboratories as learning media has a major influence on students' success in practicing Industrial Electronics courses. The virtual media laboratory can also meet students' individual needs and motivate them to use the tool. Altable (2019) examined the effect of using virtual laboratories on 116 first-year Electrical Engineering students at the University of Queensland, Australia. The study results indicated that students had a comprehensive material understanding, and using virtual laboratories significantly influenced their performance (Altable, 2019). Gagne et al. (1992) defined learning media as a physical means to provide convenience in delivering content or learning materials, such as books, films, videos.

Furthermore, Gagne and Briggs (1977) stated that learning media are components of learning resources that can stimulate students to learn. Reiser and Dick (1996) also explain that the media is an infrastructure consisting of chalk, blackboards, textbooks, videos, tapes, recorders, computers, overhead projectors, which can support student learning success.

This virtual laboratory media is designed to have advantages that can be used for learning activities, and this virtual laboratory media has advantages including:

1. Students can use this virtual laboratory media anytime and anywhere in simulating the assemblage of industrial electronics circuits and their measuring;
2. This virtual laboratory media can provide convenient indirect learning without using real and complicated equipment;
3. This virtual laboratory media can streamline the time used during the learning process, so it is very effective in practical activities in the Industrial Electronics course.

This virtual laboratory media also has drawbacks, namely:

1. This virtual laboratory media is used with an internet network; if it is not adequate, it cannot be used as a learning medium;
2. This virtual laboratory media is based on Android.

This virtual media laboratory is designed to meet the learning needs of students of the 3rd semester of the Electronic Engineering Study Program, State University of Jakarta. The virtual laboratory media was developed based on an analysis of the needs in the field and made

it easier for students to practice Industrial Electronics courses. Electronic Engineering students at the State University of Jakarta have high hopes for this virtual laboratory media to support success in practical learning activities for Industrial Electronics courses. Based on the results of a survey conducted by researchers, 95% of the students strongly agree with the existence of virtual laboratory media as a means of practice rather than using real complicated equipment. The virtual laboratory media is also equipped with instructions for its use during the learning process to make it easier for students to simulate assembling Industrial Electronics circuits and measuring Industrial Electronics circuits.

The utilization of Android-based virtual laboratory media facilitates learning process activities. However, it can also open opportunities for providers to provide the best service, from application features offered to customers to increasing profits for them. The selection of a relatively low price will be an option for Android users in enjoying the breadth of the internet network, which is very helpful and makes human work easier. In the field of Education, internet networks that some Indonesian people can enjoy great support learning activities to be accessed anywhere and anytime to make it easier for students to learn. Lebanoff (2020) in his thesis research on virtual learning experiments in engineering education. In the surveys, students provided positive feedback on creating a virtual laboratory implemented in the fall. This virtual laboratory project is expected to enhance the development of more experiments that support engineering education at the University of Central Florida. The Ministry of Education and Research in Germany (BMBF) collaborates with three universities in outstanding teaching, and the most extensive research is conducted in engineering science. Previous research of the three universities involved, RWTH Aachen University, Ruhr-Universität Bochum, and T.U. Dortmund University is a project of a remote development center and virtual laboratory for mechanical engineering education focused on manufacturing technology. For distance education, a virtual laboratory has been developed to conduct experiments in it visually (Grodotzki et al., 2018).

Laboratory virtual media was also developed for problem-solving in constructing laboratory simulations for pneumatics, a simple experiment on a single-acting cylinder operated by a pneumatic switch. The experiment included full use of Vive gear, in which students were in a completely immersive 3D virtual reality environment, including the use of a controller to simulate the real environment (dela Cruz & Mendoza, 2018). Virtual laboratories provide solutions and are very helpful for Engineering students in overcoming problems in learning than conventional laboratories (Kapilan et al., 2021). The technology acceptance model is a theoretical model that is very useful in helping understand and explain user acceptance of an online learning environment that combines virtual laboratories with practical work. The technology acceptance model also has a significant effect that has theoretical and practical implications in improving web-based education and resources (Estriegana et al., 2019). These studies also prove that virtual laboratory media is very helpful in student learning success. Besides saving time, it can also save costs from practicing with real equipment. The virtual laboratory media makes it easy for students to assemble industrial electronics circuits and measure them.

4. Conclusion

The results of a survey of Electronic Engineering students on virtual laboratory media showed a positive response, although some students did not subscribe to the internet at their homes. The data shows that 95% of students responded strongly agree and agree. Before practical activities are carried out, students see practical simulations on virtual laboratory media first to make it easier to assemble industrial electronics circuits and measure industrial electronics circuits. Students also feel happy and motivated by virtual laboratory media during the learning process during the pandemic. However, virtual laboratory media can be used not only during the pandemic but also face-to-face in the practical activities in the learning process, especially in Industrial Electronics courses. This virtual laboratory media can be used anywhere and anytime without a limited time, with the internet network.

The implication is that a virtual laboratory makes it easier for students to do practicum during the COVID-19 pandemic. Virtual laboratories can improve student skills in the field of industrial electronics. The limitation of this research is that the system developed is only based on Android, so students who do not have an Android system cannot take advantage of a virtual laboratory, so further research needs to be done with a web-based system.

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