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Virtual Laboratory as A New Educational Trend Post Covid-19: An Effectiveness Study

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ABSTRAK

Laboratorium Virtual merupakan salah satu trend pelaksanaan pembelajaran praktik jarak jauh yang populer pada pendidikan vokasi selama pandemi covid-19 hingga pasca covid-19, baik sebagai pengganti atau pelengkap pembelajaran di laboratorium nyata. Penelitian ini membahas tentang analisis efektivitas Laboratorium Virtual sebagai media pembelajaran praktik untuk mendukung pelaksanaan pembelajaran jarak jauh atau pembelajaran dalam jaringan (Daring). Tujuan dari penelitian ini adalah menganalisis efektivitas dari Laboratorium Virtual sebagai media pembelajaran dalam proses pembelajaran Praktikum Elektronika Daya pada masa pasca covid-19. Jenis penelitian yang diterapkan adalah Pre-experimental Design dengan desain One-Group Pretest-Posttest. Rubrik penilaian kinerja digunakan sebagai instrumen pengumpul data penelitian. Efektivitas virtual laboratory diketahui dari hasil analisis perbedaan nilai pretest dan posttest menggunakan paired sample t-test. Sedangkan, analisis effect size cohen's d digunakan untuk menentukan besar efek. Hasil penelitian menunjukkan bahwa virtual laboratory efektif digunakan sebagai media pembelajaran praktikum dengan besar efek pada kategori besar. Dengan demikian dapat disimpulkan bahwa Laboratorium Virtual dapat menjadi pilihan pelaksanaan pembelajaran praktik yang efektif dalam mendukung pelaksanaan pembelajaran jarak jauh.

ABSTRACT

The virtual laboratory is one of the popular trends for implementing remote learning in vocational education during the COVID-19 to Post-COVID-19 pandemic, either as a substitute or as a complement to learning in a Real Laboratory. This study discusses the effectiveness analysis of the virtual laboratory as a practicum learning media to support remote or online learning implementation. The purpose of this study was to analyses the virtual laboratory's effectiveness as a learning media in the learning process of the Power Electronics Practicum in Post-COVID-19. The type of research applied is a Pre-experimental Design with a One-Group Pretest-Posttest design. The Performance Appraisal Rubric is used as an instrument to collect research data. The virtual laboratory's effectiveness is known from the difference analysis of pretest and post-test scores using the Paired Sample T-test. Meanwhile, Cohen's d effect size analysis was used to determine the effect size. The results showed that the virtual laboratory was effectively used as a practicum learning media with a large effect category. Thus, it can be concluded that the virtual laboratory can be an effective choice for implementing practical learning in supporting the implementation of remote learning.

1. INTRODUCTION

Vocational Education is one of the educational programs aiming to produce competent graduates according to their expertise and ready-to-work. These graduates are expected to have competencies and abilities that are by those required by industry and the world of work (IDUKA) (Korber & Oesch, 2019; Zakaria et al., 2022; Zhou et al., 2022). Based on this fact, the implementation of vocational education

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must continue to experience changes, development, and innovation for better and by the changes and developments in IDUKA. In addition, the implementation of this vocational education is also adaptive to the development of science, technology, and art (IPTEKS) (Cattaneo et al., 2022; Eliza et al., 2019).

Vocational education is not only oriented to theoretical abilities but is more dominant to the mastery of practical abilities or oriented to specific skill competencies (Antonietti et al., 2022; S. J. Choi et al., 2019). Therefore, the learning process in vocational education is carried out in two forms of learning, namely theoretical learning and practical learning. Practical knowledge is carried out not only to help students understand the theory contained in the learning material but also to improve students' psychomotor competence (Byun et al., 2020; Korber & Oesch, 2019). Thus, students will have good practical skills. With this practical learning, students are expected to have sound theoretical and practical abilities (Su Jung Choi et al., 2019; Christidis, 2019). Based on the two learning implementation processes, in general, the learning media used are divided into two, namely theory learning media and practical learning media. Practical learning media can be in the form of practicum equipment, practicum materials, instructions for using practicum, job sheets, and lab sheets which in general are carried out in the laboratory (Byun et al., 2020; Korber & Oesch, 2019). This is certainly different from theoretical learning which is carried out in the classroom, not in the laboratory with the equipment.

The COVID-19 pandemic which occurred at the end of 2019, caused some rapid changes in the community environment, especially in the way they interact and communicate (Abumalloh et al., 2021; Ismaeel & Al Mulhim, 2022). With the limitation of face-to-face meetings, the choice of long-distance communication is a very important requirement and is experiencing a very significant increase in usage (Indrawati, 2020; Octaberlina & Muslimin, 2020). The learning process in educational institutions is one of the sectors that has experienced rapid changes during the Covid-19 pandemic. The learning process that was previously carried out face-to-face in class, must be carried out remotely or known as remote learning (Code et al., 2020; Valverde-Berrocoso et al., 2021). This rapid change certainly requires educators to continue to make innovations in carrying out the learning process. These innovations are innovations in models, methods, strategies, and learning media that can be applied in the learning process. Thus, the implementation of learning continues well and can achieve learning objectives optimally even though it is not carried out face-to-face in class.

Learning process changes at the beginning of the Covid-19 pandemic also occurred in the implementation of vocational education both in secondary and higher education. Vocational education, which has a more dominant practical learning process than theoretical learning, certainly requires more innovation in terms of models, strategies, methods, and learning media, especially practical learning (Maulana & Iswari, 2020; Syauqi et al., 2020; J. Wang et al., 2021). Several innovations have been made to make practical learning remotely run optimally and face-to-face learning in real laboratories, especially in practicum learning media (Abumalloh et al., 2021; Estriegana et al., 2019; Viitaharju et al., 2021). Several choices of practicum learning media have emerged during the covid-19 pandemic, such as videos, animations, and virtual laboratories that have been designed so that they become representations of real laboratories (Day et al., 2021; Jaya et al., 2016; Viitaharju et al., 2021).

The virtual laboratory is one of the widely used learning media and its use has increased significantly in the learning process during the COVID-19 pandemic (Estriegana et al., 2019; Gunawan et al., 2019; Potkonjak et al., 2016). Learning that was previously carried out face-to-face in the laboratory, was then carried out using a virtual laboratory without face-to-face. So, the practical learning process can be done anytime and anywhere. A virtual laboratory is a form of laboratory where computer software is used to observe or carry out experimental activities in the learning process (Abumalloh et al., 2021; Husnaini & Chen, 2019). Virtual laboratories are designed with the same form, function, atmosphere, tools, and practicum materials as real laboratories. In other words, the virtual laboratory is a representation of a real laboratory, so the experience of students in carrying out practical learning when using a virtual laboratory remains the same as the learning process in a real laboratory (Alkhaldi et al., 2016; Kapilan et al., 2021; Nolen & Koretsky, 2018). Several previous research results show that virtual laboratories are effectively used as learning media in the practicum learning process for students of science, engineering, and vocational education (Chin et al., 2021). In addition, virtual laboratories can also help optimize the implementation of practical learning even though it is carried out remotely and not in a real laboratory (Estriegana et al., 2019).

At the beginning of 2022, along with the decline in active cases of Covid-19, the learning process was gradually carried out face-to-face. Blended learning is becoming popular to be implemented in the implementation of learning in various countries including Indonesia (Arifin, 2020; Kusdiyanti et al., 2020). Blended Learning is a mixed learning process between face-to-face learning in the classroom and online learning (Jaya Saragih et al., 2020; Subandowo et al., 2020). The virtual laboratory is still used as a practicum learning media combined with face-to-face learning in a real laboratory. Then, how effective is

the use of a virtual laboratory as a practical learning media in blended learning? Is it still as effective as when it is implemented in fully remote learning? There are still few research articles that discuss this topic, especially its application in the field of vocational education which is more dominant in practical learning. Therefore, it is necessary to conduct research that can reveal the effectiveness of using virtual laboratories in blended learning as an effort to optimize the implementation of practical learning in the post-covid-19. The purpose of this study was to reveal the effectiveness of using a virtual laboratory as a practicum learning media for Vocational Education students in the field of Industrial.

2. METHOD

This research is experimental research using a Pre-experimental Design. Pre-experimental design is a study that does not have a control group, and the sample is not selected randomly (Gopalan et al., 2020; Madadizadeh, 2022). While in practice the form of research design used in this study is the One-Group Pretest-Posttest. The pretest is a test carried out before the implementation of the research action which aims to measure the students' initial ability before being given the research action. The research action that was experimented with in this study was the implementation of a remote learning process using a virtual laboratory in the Power Electronics Practicum learning process for Industrial Electrical Engineering vocational education students. Meanwhile, the Posttest is a test that is held after the research activity is carried out which aims to measure the final ability of students after participating in the practical learning process using a virtual laboratory in the Power Electronics Practicum learning process.

The research subjects in this study were 22 students of vocational education D4 Industrial Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang, Indonesia. These 22 students were joined in one experimental class. These students will be assessed for their practicum performance by the lecturer as an observer in this study. Performance appraisal is done by filling out the performance appraisal rubric that has been prepared as a research instrument.

The research instrument used in this study was a performance assessment rubric used for the pretest and posttest. The performance assessment rubric used in this study has been tested for validity and reliability. The instrument validity test was carried out by analysis using the Pearson Product Moment Correlation while the reliability test was analyzed by Cronbach's Alpha reliability analysis. The results of the validity analysis show that the calculated r value for all indicators is greater than the r table (> 0.361). So, it can be seen that all indicators in the research instrument are valid. The results of the instrument reliability analysis using Cronbach's alpha obtained a Cronbach's alpha value of 0.815. Because Cronbach's alpha value is greater than 0.60 (0.815> 0.600), it can be seen that the research instrument in the form of a performance assessment rubric is declared reliable. The research instrument in the form of a performance assessment rubric is structured based on the dimensions and indicators presented in Table 1.

Table 1. Dimensions and Indicators of Research Instrument

Dimensions	Indicators
Preparation Stage	1. Prepare practicum tools according to practicum topics
	2. Prepare practicum materials according to practicum topics
	3. Arrange the layout of tools and practicum materials by the circuit drawings on the job sheet
	4. Connect tools and materials into a series of experiments according to the circuit drawings on the job sheet
Implementation stage	5. Use practical tools and materials correctly, according to their function.
	6. Carry out each practicum stage correctly and follow the practicum steps on the job sheet
	7. Focusing attention on practicum activities / not teaching other things that are not related to practicum procedures
	8. Have an interest in practicum activities
	9. Actively involved in practicum activities
	10. Observe the practical results carefully
Closing and reporting stage	11. Interpret observations correctly
	12. Presenting data in a systematic and communicative manner
	13. Analyse data inductively
	14. Make conclusions that are by the results of practice

This valid and reliable performance assessment rubric will be used by lecturers as observers to assess student practicum performance. The assessment was carried out before and after the research action was given in the form of power electronics practice learning using a virtual laboratory. The data collected in this study is student practice performance data obtained through research instruments. Research data is divided into two, namely pretest data and posttest data. The normality test of the data using the Kolmogorov-Smirnov Z normality analysis was carried out before the effectiveness analysis.

The effectiveness of the virtual laboratory in the power electronics practicum learning process is known through two analytical techniques, namely analysis using paired sample t-test analysis and Cohen's d Effect Size analysis. Paired sample t-test is an analysis to determine whether there is a significant difference between pretest and posttest data. Meanwhile, Cohen's d Effect Size is an analysis to determine the magnitude of its effectiveness. All data analysis was carried out using the SPSS application.

The effect size value obtained through Cohen's d Effect Size analysis is then interpreted with the effect size criteria table to determine the effect category of the given research action, namely the power electronics practicum learning process using a virtual laboratory. Based on the results of the interpretation, it will be known the effectiveness of the virtual laboratory when used as a practical learning media. The effect size criteria table based on Cohen's d value is presented in Table 2.

Table 2. Effect Size Criteria

No.	d Value Range	Categories
1	0,8 ≤ d ≤ 2,0	Big
2	0,5 ≤ d < 0,8	Medium
3	0,2 ≤ d < 0,5	Small

3. RESULT AND DISCUSSION

Result

A virtual laboratory is computer software that is used to observe or carry out experimental activities in the learning process. The virtual laboratory is designed with the form, function, atmosphere, tools, and practicum materials which are relatively the same as the real laboratory. In other words, the virtual laboratory is a representation of a real laboratory so that the experience of students in participating in practical learning remains the same as learning in a real laboratory. In this study, the virtual laboratory used was a computer-based power electronics circuit simulator application, namely the PowerSim (PSim) application. PSim is a simulation software specially designed for power electronics, motor drives,s and power conversion systems. With fast simulation speed, PSim provides powerful simulation to meet simulation and development needs. PSim consists of PSim schematic program, a Simulation Engine, and waveform processing. With the completeness of these features, it is possible to use it as a virtual learning media. Students can do experiments like in a real laboratory such as choosing components, determining the layout of components, assembling components, to conducting circuit trials. this is because the form of experimental action in this application is a representation of experiments carried out directly in the laboratory. The virtual laboratory applied in this study is presented in Figure 1.

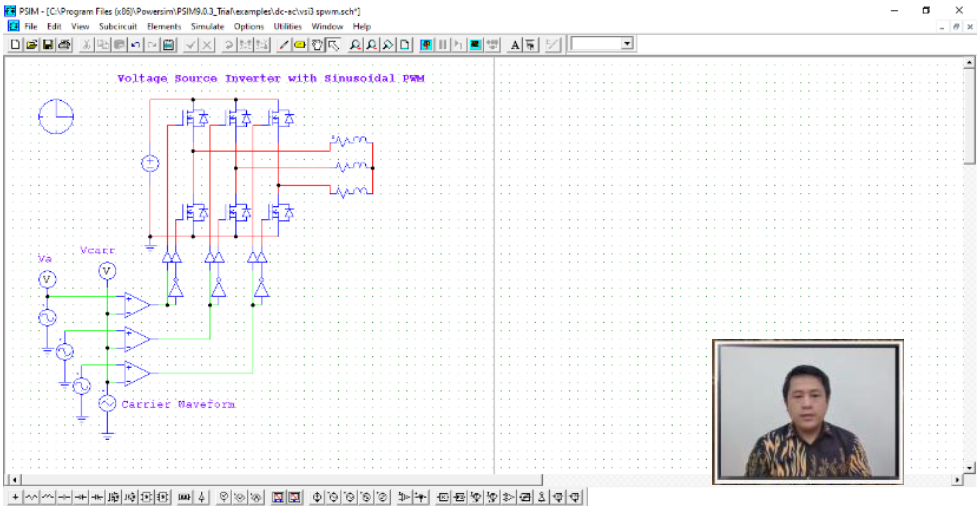

Figure 1. The Virtual Laboratory Applied in This Study

The data obtained in this study is data from the results of filling out the rubric for evaluating student practicum performance which is filled out by the lecturer as an observer. Following the planned research design, data collection was carried out twice, namely before the research action (Pretest) and after the research action was given (Posttest). The research activity carried out was the power electronics practicum learning process using a virtual laboratory as a learning media.

The pretest is an initial test conducted on students. The results of the pretest are used to see the initial abilities of students before getting research treatment in the form of a power electronics practicum learning process carried out using a virtual laboratory. The pretest data were obtained through the results of the practicum performance assessment of each student by filling out the performance appraisal rubric by the lecturer as a research observer. Pretest data is one of the data needed in conducting data analysis to determine the effectiveness of the implementation of virtual laboratories in the learning process.

The results of the pretest data analysis show that the minimum value of student practicum performance before using the virtual laboratory is 45 and the maximum value is 85. The average value of the practicum performance of 22 students is 65 with a standard deviation of 9.798. The normality test of the pretest data was carried out before it could be used for effectiveness analysis using effect size. The results of testing the normality of the pretest data using the Kolmogorov-Smirnov Z formula are presented in Table 3.

Table 3. The Results of Normality Test Analysis of Pretest Data

		Pretest Score
N		22
Normal Parameters	Mean	65,00
	Std. Deviation	9,798
Most Extreme Differences	Absolute	0,100
	Positive	0,074
	Negative	-0,100
Kolmogorov-Smirnov Z		0,548
Asymp. Sig. (2-tailed)		0,925

The results of the pretest data normality test in Table 3 show a significance value of 0.925 which is greater than the standard alpha value of 0.05. Thus, it can be seen that the pretest data is normally distributed ($\alpha = 0.649 > 0.05$). Thus, this pretest data can be analyzed further, namely an analysis of the effectiveness of using a virtual laboratory in the learning process of power electronics practicum.

The posttest is the final assessment of the student's practical performance after the research activities in the form of a power electronics practicum learning process that applies a virtual laboratory as a learning media has been completed. Posttest was conducted to obtain data on the final ability of students as research subjects after getting research actions. Posttest data were obtained through the results of the practicum performance assessment of each student based on the results of filling out the performance assessment rubric conducted by the lecturer. This posttest data complements the data used for effectiveness analysis apart from the pretest data that has been obtained previously.

The results of the posttest data analysis show that the minimum value of student practicum performance after using the virtual laboratory is 60 and the maximum value is 95. The average value of the practicum performance of 22 students is 80 with a standard deviation of 7,575. The normality test of the posttest data was carried out before it could be used for effectiveness analysis using effect size. The results of testing the normality of the posttest data using the Kolmogorov-Smirnov Z formula are presented in Table 4.

Table 4. The Results of Normality Test Analysis of Posttest Data

		Posttest Score
N		22
Normal Parameters	Mean	80,00
	Std. Deviation	7,575
Most Extreme Differences	Absolute	0,135
	Positive	0,079
	Negative	-0,135
Kolmogorov-Smirnov Z		0,737
Asymp. Sig. (2-tailed)		0,649

The results of the posttest data normality test in Table 4 show a significance value of 0.649 which is greater than the standard alpha value of 0.05. Thus, it can be seen that the posttest data is normally distributed (α = 0.649 > 0.05). Thus, this posttest data can be analyzed further, namely an analysis of the effectiveness of using a virtual laboratory in the learning process of power electronics practicum.

The effectiveness of using a virtual laboratory as a practical learning media in the power electronics teaching process was first revealed by paired sample t-test analysis. The aim is to determine whether significant differences exist in student learning outcomes before and after participating in the power electronics practicum learning process using a virtual laboratory. The results of the paired sample t-test analysis show that the value of t count > t table (7.479 > 1.721) and an alpha significance value that is smaller than 0.05 (0.000 < 0.05). Thus, it can be stated that there is a significant difference between the pretest and posttest student practicum performance scores, where the student practicum performance scores on the posttest are better than the student practicum performance scores on the pretest. This can be seen through the average posttest being greater than the average pretest (80> 65). Thus, it can be stated that the virtual laboratory is effectively used as a practical learning media in the power electronics practicum learning process for vocational education students in online learning or remote learning.

The magnitude of the effect of the virtual laboratory used as a learning media in the power electronics practicum learning process was analyzed using Cohen's d Effect Size analysis. The results of the effect size analysis between the pretest and posttest data obtained an effect index value of 1.98 (d = 1.98). If it is interpreted with the effect size criteria table, this effect is an influence with a large/high category. The results of the effect size analysis and the interpretation of the effect size category show that the virtual laboratory is effectively used as a practical learning media in the power electronics practicum learning process. The magnitude of the effect given is included in the large or high category. Thus, it can be seen that the effectiveness of using a virtual laboratory in the learning process of power electronics practicum is high/large. the use of a virtual laboratory in practical learning can be a choice for implementing effective practical learning, especially for remote learning in addition to the practicum learning process with a face-to-face system in a real class/laboratory.

Discussion

The virtual laboratory is computer software used to observe or perform experimental activities. This virtual laboratory is designed to have the same shape, atmosphere, practicum tools & materials, and functions as a real laboratory. In other words, a virtual laboratory is a representation of a real laboratory. So, it is hoped that the experience of students in the practical learning process using a virtual laboratory will remain the same as the learning process in a real laboratory (Alkhaldi et al., 2016; Kapilan et al., 2021). Research results from several previous researchers indicate that virtual laboratories can be used as an alternative choice for implementing practical learning when the face-to-face learning process in the laboratory cannot be implemented (Ibrahem et al., 2022; Setiawan et al., 2015). In addition, the virtual laboratory is also effectively used as an auxiliary learning media in optimizing the implementation of learning in a real laboratory. The use of a virtual laboratory as an auxiliary media in the direct learning process in a real laboratory will result in a varied practical learning process. thus, increasing student interest and motivation in the learning process.

In this study, the virtual laboratory used is a computer-based power electronics circuit simulator application, namely the Power Simulator (PSim) application. PSim is a simulation software specifically designed for the needs of power electronics, motor drives, and power conversion systems (Ding & Wang, 2017; K. Wang & Kumar, 2022). With fast simulation times, PSim provides powerful simulations to meet simulation and development needs. PSim consists of the PSim schematic program, Simulation Engine, and waveform processing. With the completeness of these features, PSim allows it to be used as a virtual practicum learning media (Krismadinata et al., 2019; K. Wang & Kumar, 2022). Students can carry out experimental activities in real laboratories such as choosing components, compiling component layouts, assembling components, and simulating circuit operations. The use of PSim is effectively used for engineering and vocational learning processes such as electronics, electricity, control, control, and automation (Ding & Wang, 2017; K. Wang & Kumar, 2022). Some of the characteristics and advantages offered by PSim are reasons for implementing PSim as a virtual laboratory in blended learning in the power electronics practicum learning process for vocational education students in an effort to optimize learning implementation.

The results of the effectiveness analysis using the paired sample t-test and the effect size were analyzed using Cohen's d effect size showing that the virtual laboratory is effectively used as a practical learning media in the learning process of power electronics practicum for vocational education students in industrial electrical engineering. The size of the effect determined based on the interpretation of the value of d with the effect size criteria table shows that the effect provided by the virtual laboratory as a

remote learning media is in the high/large category. Several previous research results also show that the effect size of the use of virtual laboratories is also in the medium and high categories (Abumalloh et al., 2021; Gunawan et al., 2019). This indicates that the virtual laboratory has high effectiveness in a practical learning process, especially in power electronics practicum. Some research results conducted by previous researchers also show that the use of virtual laboratories as practical learning media, is effective to be applied to learning processes that require practicum activities such as in the fields of biology, Chemistry, physics, engineering, and health (as a substitute or complement to real laboratories) (Gunawan et al., 2018; K. Wang & Kumar, 2022).

The research results have implications for the optimal implementation of power electronics practicum learning through the application of a virtual laboratory as a practicum learning media for vocational education students in industrial electrical engineering, faculty of engineering, Padang State University. The effectiveness of using a virtual laboratory as a practicum learning media revealed in this study has implications for alternative choices for implementing practical learning. So, it can not only be implemented using a real laboratory but also a virtual laboratory or a combination of both. The learning process in the vocational education field with more dominant practicum activities can make the virtual laboratory an option for implementing practical learning besides implementing it in a real laboratory. The implementation of practicum learning using a virtual laboratory can be a substitute or complement to the learning process in a real laboratory.

This research is limited to the implementation of a virtual laboratory in one learning process, namely power electronics practicum at vocational education in the field of industrial electrical engineering. Therefore, the effectiveness revealed in this study is only the effectiveness of a virtual laboratory when used as a practicum learning media in the power electronics practicum learning process for vocational education students in the field of industrial electrical engineering. With the limitations of this research, it is recommended that future researchers be able to research the effectiveness of using virtual laboratories in other learning processes in vocational education or other fields with a larger number of research subjects. The type of virtual laboratory to be used can also vary according to the characteristics of the material and implementation of learning. Thus, it will be able to multiply and strengthen research information related to the effectiveness of using virtual laboratories as an alternative to implementing practical learning besides implementing in real laboratories. The virtual laboratory can act as a substitute or complement to the real laboratory.

4. CONCLUSION

A virtual laboratory is a laboratory where computer-operated software is used to observe or perform experimental activities. The virtual laboratory is designed to have the same shape, atmosphere, tools & materials, and functions that are the same as a real laboratory. In other words, a virtual laboratory is a form of representation of a real laboratory that can make the experience of students in the practical learning process the same as practical learning in a real laboratory. The results showed that the virtual laboratory was effectively used as a media for practical learning in the learning process of power electronics practicum for vocational education students in industrial electrical engineering. The magnitude of the effect of the use of this virtual laboratory is also included in the high or large category. this indicates that the virtual laboratory has high effectiveness in a practical learning process. Virtual laboratories are effectively used as practical learning media for vocational education students and can be used as a choice for implementing practical learning either separately or in combination with face-to-face learning in real laboratories.

5. REFERENCES

Abumalloh, R. A., Asadi, S., Nilashi, M., Minaei-Bidgoli, B., Nayer, F. K., Samad, S., Mohd, S., & Ibrahim, O. (2021). The impact of coronavirus pandemic (COVID-19) on education: The role of virtual and remote laboratories in education. *Technology in Society*, *67*(September 2020), 101728. https://doi.org/10.1016/j.techsoc.2021.101728.

Alkhaldi, T., Pranata, I., & Athauda, R. I. (2016). A review of contemporary virtual and remote laboratory implementations: observations and findings. *Journal of Computers in Education*, *3*(3), 329–351. https://doi.org/10.1007/s40692-016-0068-z.

Antonietti, C., Cattaneo, A., & Amenduni, F. (2022). Can teachers' digital competence influence technology acceptance in vocational education? *Computers in Human Behavior*, *132*. https://doi.org/10.1016/J.CHB.2022.107266.

Arifin, M. (2020). The Effect of Blended Learning Model with Moodle on the Students' Writing

Achievement. *IJEMS:Indonesian Journal of Education and Mathematical Science*, *1*(2), 19. https://doi.org/10.30596/ijems.v1i2.4639.

Byun, Y. J., Lee, S. H., & Kim, J. (2020). A Study on Developing the Model of Learner Satisfaction in Synchronous Online Entrepreneurship Education. *International Journal of Entrepreneur and Business*, *21*(2). https://doi.org/10.15813/kmr.2020.21.2.007.

Cattaneo, A. A. P., Antonietti, C., & Rauseo, M. (2022). How digitalised are vocational teachers? Assessing digital competence in vocational education and looking at its underlying factors. *Computers & Education*, *176*. https://doi.org/10.1016/J.COMPEDU.2021.104358.

Chin, K. E., Kwon, D. H., Gan, Q., Ramalingam, P. X., Wistuba, I. I., Prieto, V. G., & Aung, P. P. (2021). Transition from a standard to a hybrid on-site and remote anatomic pathology training model during the coronavirus disease 2019 (covid-19) pandemic. *Archives of Pathology and Laboratory Medicine*, *145*(1), 22–31. https://doi.org/10.5858/arpa.2020-0467-SA.

Choi, S. J., Jeong, J. C., & Kim, S. N. (2019). Impact of vocational education and training on adult skills and employment: An applied multilevel analysis. *International Journal of Educational Development*, *66*. https://doi.org/10.1016/j.ijedudev.2018.09.007.

Choi, Su Jung, Jeong, J. C., & Kim, S. N. (2019). Impact of vocational education and training on adult skills and employment: An applied multilevel analysis. *International Journal of Educational Development*, *66*(12), 129–138. https://doi.org/10.1016/j.ijedudev.2018.09.007.

Christidis, M. (2019). Vocational knowing in subject integrated teaching: A case study in a Swedish upper secondary health and social care program. *Learning, Culture and Social Interaction*, *21*. https://doi.org/10.1016/j.lcsi.2019.01.002.

Code, J., Ralph, R., & Forde, K. (2020). Pandemic designs for the future: perspectives of technology education teachers during COVID-19. *Information and Learning Science*, *121*(5–6), 409–421. https://doi.org/10.1108/ILS-04-2020-0112.

Day, T., Chang, I. C. C., Chung, C. K. L., Doolittle, W. E., Housel, J., & McDaniel, P. N. (2021). The Immediate Impact of COVID-19 on Postsecondary Teaching and Learning. *Professional Geographer*, *73*(1), 1–13. https://doi.org/10.1080/00330124.2020.1823864.

Ding, S., & Wang, F. (2017). A New Negative Output Buck-Boost Converter with Wide Conversion Ratio. *IEEE Transactions on Industrial Electronics*, *64*(12), 9322–9333. https://doi.org/10.1109/TIE.2017.2711541.

Eliza, F., Suriyadi, S., & Yanto, D. T. P. (2019). Peningkatan Kompetensi Psikomotor Siswa Melalui Model Pembelajaran Project Based Learning (PjBL) di SMKN 5 Padang : PDS Project. *INVOTEK: Jurnal Inovasi Vokasional Dan Teknologi*, *19*(2). https://doi.org/10.24036/invotek.v19i2.427.

Estriegana, R., Medina-Merodio, J. A., & Barchino, R. (2019). Student acceptance of virtual laboratory and practical work: An extension of the technology acceptance model. *Computers and Education*, *135*. https://doi.org/10.1016/j.compedu.2019.02.010.

Gopalan, M., Rosinger, K., & Ahn, J. Bin. (2020). Use of Quasi-Experimental Research Designs in Education Research: Growth, Promise, and Challenges. *Review of Research in Education*, *44*(1), 218–243. https://doi.org/10.3102/0091732X20903302.

Gunawan, G., Nisrina, N., Suranti, N. M. Y., Herayanti, L., & Rahmatiah, R. (2018). Virtual laboratory to improve students' conceptual understanding in physics learning. *Journal of Physics: Conference Series*, *1108*(1), 012049. https://doi.org/10.1088/1742-6596/1108/1/012049.

Gunawan, Harjono, A., Hermansyah, & Herayanti, L. (2019). Guided inquiry model through virtual laboratory to enhance students' science process skills on heat concept. *Cakrawala Pendidikan*, *38*(2), 259–268. https://doi.org/10.21831/cp.v38i2.23345.

Husnaini, S. J., & Chen, S. (2019). Effects of guided inquiry virtual and physical laboratories on conceptual understanding, inquiry performance, scientific inquiry self-efficacy, and enjoyment. *Physical Review Physics Education Research*, *15*(1). https://doi.org/10.1103/PhysRevPhysEducRes.15.010119.

Ibrahem, U. M., Alsaif, B. S., Alblaihed, M., Ahmed, S. S. I., Alshrif, H. A., Abdulkader, R. A., & Diab, H. M. (2022). Interaction between cognitive styles and genders when using virtual laboratories and its influence on students of health college's laboratory skills and cognitive load during the Corona pandemic. *Heliyon*, *8*(4), 1–8. https://doi.org/10.1016/j.heliyon.2022.e09213.

Indrawati, B. (2020). Tantangan dan Peluang Pendidikan Tinggi Dalam Masa dan Pasca Pandemi Covid-19. *Jurnal Kajian Ilmiah*, *1*(1), 39–48. https://doi.org/10.31599/jki.v1i1.261.

Ismaeel, D. A., & Al Mulhim, E. N. (2022). E-teaching Internships and TPACK during the Covid-19 Crisis: The Case of Saudi Pre-service Teachers. *International Journal of Instruction*, *15*(4). https://doi.org/10.29333/iji.2022.1549a.

Jaya, H., Haryoko, S., & Dirawan, G. D. (2016). Effectiveness the use of Virtual Laboratories in Improving

Vocational Competence and Character Behavior for Students Vocational High School in Makassar. *International Journal of Applied Engineering Research*, *11*(9), 6396–6401. http://eprints.unm.ac.id/13089/.

Jaya Saragih, M., Mas Rizky Yohannes Cristanto, R., Effendi, Y., & Zamzami, E. M. (2020). Application of Blended Learning Supporting Digital Education 4.0. *Journal of Physics: Conference Series*, *1566*(1), 0–6. https://doi.org/10.1088/1742-6596/1566/1/012044.

Kapilan, N., Vidhya, P., & Gao, X.-Z. (2021). Virtual laboratory: A boon to the mechanical engineering education during covid-19 pandemic. *Higher Education for the Future*, *8*(1), 31–46. https://doi.org/10.1177/2347631120970757.

Korber, M., & Oesch, D. (2019). Vocational versus general education: Employment and earnings over the life course in Switzerland. *Advances in Life Course Research*, *40*. https://doi.org/10.1016/j.alcr.2019.03.003.

Krismadinata, A., Husnaini, I., Candra, O., & Myori, D. E. (2019). Performance analysis of three-phase controlled rectifier in various switching angles. *International Journal of Engineering and Advanced Technology*, *9*(1), 1959–1965. https://doi.org/10.35940/ijeat.A9524.109119.

Kusdiyanti, H., Zanky, N., & Mokhammad Prasetyo Wati, A. (2020). Blended Learning for Augmented Reality to Increase Student Competitiveness the Filling Subject Toward Making Indonesia 4.0. *KnE Social Sciences*, 88–100. https://doi.org/10.18502/kss.v4i7.6845.

Madadizadeh, F. (2022). A tutorial on Quasi-experimental designs. *Journal of Community Health Research*, *11*(1), 3–4. https://iranjournals.nlai.ir/bitstream/handle/123456789/916068/B056CA7D2AA0554C0E7FEFF379D08F6C.pdf?sequence=-1.

Maulana, H. A., & Iswari, R. D. (2020). Analisis Tingkat Stres Mahasiswa Terhadap Pembelajaran Daring Pada Mata Kuliah Statistik Bisnis Di Pendidikan Vokasi. *Khazanah Pendidikan*, *14*(1), 17–30. https://doi.org/10.30595/jkp.v14i1.8479.

Nolen, S. B., & Koretsky, M. D. (2018). Affordances of Virtual and Physical Laboratory Projects for Instructional Design: Impacts on Student Engagement. *IEEE Transactions on Education*, *61*(3), 226–233. https://doi.org/10.1109/TE.2018.2791445.

Octaberlina, L. R., & Muslimin, A. I. (2020). Efl students perspective towards online learning barriers and alternatives using moodle/google classroom during covid-19 pandemic. *International Journal of Higher Education*, *9*(6), 1–9. https://doi.org/10.5430/ijhe.v9n6p1.

Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guetl, C., Petrović, V. M., & Jovanović, K. (2016). Virtual laboratories for education in science, technology, and engineering: A review. *Computers and Education*, *95*, 309–327. https://doi.org/10.1016/j.compedu.2016.02.002.

Setiawan, H., Isnaeni, W., Budijantoro, F. P. M. H., & Marianti, A. (2015). Implementation Of Learning Using Interactive Multimedia In Excretory System With Virtual Laboratory. *Research and Evaluation in Education Journal*, *1*(2), 212–224. https://doi.org/10.21831/reid.v1i2.6501.

Subandowo, M., Asri Humaira, M., Rusmiati Aliyyah, R., Rachmadtullah, R., Samsudin, A., & Nurtanto, M. (2020). Use of Blended Learning with Moodle: Study Effectiveness in Elementary School Teacher Education Students during The COVID-19 pandemic Kedisiplinan dalam Manajemen kelas View project Use of Blended Learning with Moodle: Study Effectiveness in Elementary Sc. *International Journal of Advanced Science and Technology*, *29*(7), 3272–3277. https://www.researchgate.net/profile/Achmad-Samsudin/publication/341724918_Use_of_Blended_Learning_with_Moodle_Study_Effectiveness_in_Elementary_School_Teacher_Education_Students_during_The_COVID-19_pandemic/links/5ed081c0299bf1c67d26f334/Use-of-Blended-L.

Syauqi, K., Munadi, S., & Triyono, M. B. (2020). Students' perceptions toward vocational education on online learning during the COVID-19 pandemic. *International Journal of Evaluation and Research in Education*, *9*(4), 881–886. https://doi.org/10.11591/ijere.v9i4.20766.

Valverde-Berrocoso, J., Fernández-Sánchez, M. R., Dominguez, F. I. R., & Sosa-Díaz, M. J. (2021). The educational integration of digital technologies preCovid-19: Lessons for teacher education. *PLoS ONE*, *16*(8 August), 1–22. https://doi.org/10.1371/journal.pone.0256283.

Viitaharju, P., Yliniemi, K., Nieminen, M., & Karttunen, A. J. (2021). Learning experiences from digital laboratory safety training. *Education for Chemical Engineers*, *34*, 87–93. https://doi.org/https://doi.org/10.1016/j.ece.2020.11.009.

Wang, J., Zheng, Q., Song, W., & Wei, L. (2021). The Effect of Nursing Students' Self-Efficacy on Patient-Centered Communication During the COVID-19 Pandemic: The Mediating Effect of Learning Burnout. *Frontiers in Psychiatry*, *12*(04), 1–9. https://doi.org/10.3389/fpsyt.2021.787819.

Wang, K., & Kumar, P. (2022). Virtual laboratory for understanding impact of heterogeneity on

ecohydrologic processes across scales. *Environmental Modelling & Software*, *149*, 105283. https://doi.org/10.1016/J.ENVSOFT.2021.105283.

Zakaria, N., Vouyouka, A., & Ruznan, W. S. (2022). Sustainable apparel technical and vocational education and training (TVET): integrating technology for skills training. *Digital Manufacturing Technology for Sustainable Anthropometric Apparel*. https://doi.org/10.1016/B978-0-12-823969-8.00003-4.

Zhou, N., Tigelaar, D. E. H., & Admiraal, W. (2022). Vocational teachers' professional learning: A systematic literature review of the past decade. *Teaching and Teacher Education*, *119*. https://doi.org/10.1016/J.TATE.2022.103856.