Journal of Educational Research and Evaluation
Volume 5, Issue 2, 2021, pp. 192-199
P-ISSN: 2597-422x E-ISSN: 2549-2675
Open Access: https://ejournal.undiksha.ac.id/index.php/JERE

Need Analysis of Virtual Laboratory for Vocational School Learning Practices During Covid-19 Pandemic

Eskawati Musyarofah Bunyamin[1*], Eveline Siregar[2], Dwi Kusumawardani[3]

[1,2,3] *Department of Educational Technology, Postgraduate Program, State University of Jakarta, Jakarta, Indonesia*

ARTICLE INFO

Article history:
Received February 16, 2021
Revised February 20, 2021
Accepted April 04, 2021
Available online May 25, 2021

Kata Kunci :
Pembelajaran Jarak Jauh, Laboratorium Virtual, SMK

Keywords:
Distance Learning, Virtual Laboratory, Vocational School

ABSTRAK

Selama pandemi COVID-19, sekolah tidak membuka layanan pembelajaran tatap muka. Kementerian Pendidikan dan Kebudayaan mengeluarkan kebijakan belajar dari Rumah (BDR) untuk mendukung prinsip Kebijakan Pendidikan di Masa Pandemi COVID-19 bahwa kesehatan dan keselamatan peserta didik, pendidik, tenaga kependidikan, keluarga, dan masyarakat adalah prioritas utama. Namun pembelajaran di Sekolah Menengah Kejuruan (SMK) lebih banyak berbasis praktik sehingga kegiatan BDR tidak dapat dilaksanakan. Salah satu hal yang dilakukan untuk mengatasi hal tersebut adalah beberapa kegiatan praktikum dapat dilakukan dengan menggunakan multimedia yang dikenal dengan laboratorium virtual. Penelitian ini bertujuan untuk melakukan analisis kebutuhan pengembangan laboratorium virtual untuk praktik pembelajaran SMK di masa Pandemi Covid-19. Pengembangan laboratorium virtual ini didasarkan pada pendekatan pengembangan pembelajaran berorientasi produk dan menggunakan model pengembangan William W. Lee dan Diana L. Owens. Tahap analisis kebutuhan terdiri dari penilaian kebutuhan dan analisis front-end. Analisis kebutuhan dilakukan untuk mengumpulkan data tentang kesenjangan dan kebutuhan serta profil mahasiswa yang dapat digunakan sebagai dasar atau acuan dalam mengembangkan laboratorium virtual pada tahap selanjutnya. Pengumpulan data dilakukan dengan cara observasi, wawancara, dan penyebaran kuesioner. Hasil penelitian menunjukkan bahwa dibutuhkan laboratorium virtual untuk mendukung pembelajaran praktik bagi siswa SMK. Di masa pandemi Covid-19, laboratorium virtual ini dapat digunakan untuk membantu mahasiswa mempersiapkan diri sebelum memasuki laboratorium sesungguhnya.

ABSTRACT

During the COVID-19 pandemic, schools did not open face-to-face learning services. The Ministry of Education and Culture has issued a policy learning from Home (BDR) to support the principles of the Education Policy in the COVID-19 Pandemic that the health and safety of students, educators, education personnel, families, and the community is the top priority. However, learning in Vocational School (SMK) is mostly based on practice so that BDR activities cannot be implemented. One thing that is done to overcome this is that some practicum activities can be executed using multimedia known as virtual laboratories. This study aims to conduct a need analysis for the development of a virtual laboratory for vocational school learning practices in the Covid-19 Pandemic. The development of this virtual laboratory is based on a product-oriented learning development approach and uses a model development of William W. Lee and Diana L. Owens. The needs analysis stage consists of a needs assessment and a front-end analysis. Needs analysis is carried out to gather data about gaps and needs as well profiles of students that can be used as a basis or reference in developing virtual laboratory at the next stage. Data collection was carried out by means of observation, interviews, and distributing questionnaires. The results showed that a virtual laboratory was needed to support practical learning for vocational students. During the Covid-19 pandemic, this virtual laboratory could be used to help students prepare themselves before entering the real laboratory.

1. INTRODUCTION

The Covid-19 pandemic is impacting various sectors around the world (Abidah et al., 2020; Yuzulia, 2021). One of the sectors affected is education. The Indonesian government took a policy of closing schools and not providing face-to-face learning services to support the principles of the Education Policy in the Covid-19 Pandemic where the health and safety of students, educators, education personnel, families, and the community is a top priority. The policy taken is through the Home Learning Program (BDR) (Astuti & Harun, 2020; Kurniasari et al., 2020). The Learning from Home Program (BDR) by the Ministry of Education and Culture provides alternative learning activities while children study at home due to the impact of the COVID-19 pandemic. The broadcasts in the BDR program include shows for

*Corresponding author.
E-mail addresses: EskawatiMusyarofahBunyamin_9901818001@mhs.unj.ac.id (Eskawati Musyarofah Bunyamin)

children aged PAUD and equivalent, SD and equivalent, SMP and equivalent, SMA/SMK and equivalent, and family and cultural programs. However, learning in SMK is mostly practice-based so that BDR activities cannot be fully implemented. Even though as we know, Practicum activities for vocational students play an important role because it aims to make students skilled in using tools and materials. It also can support scientific learning in a field by enabling learners to acquire practical skills through experiments and giving them the opportunity to have a deeper understanding of the content (Aljuhani et al., 2018). Activities in the laboratory also allow students to observe and interact interactively to investigate phenomena, relate data to disciplinary principles, and work with others in teams (Nolen & Koretsky, 2018). A survey conducted by the Ministry of Education and Culture's Directorate General of Vocational Education regarding the impacts arising from distance learning during the Covid-19 pandemic. The survey concluded that for the SMK level, practical learning requires the physical presence of students and teachers in the practicum room with strict health protocols.

One thing that can be done to overcome this is that some practicum activities can be simulated by utilizing multimedia, hereinafter known as virtual laboratories. In simple terms Brinson (2015), citing Ma & Nickerson, states that a virtual laboratory is an imitation of a real laboratory. All the equipment used is not real but is a simulation. The virtual laboratory is a media that is made similar and can simulate the real laboratory conditions to practice before entering the real laboratory. Virtual laboratories are not considered as substitutes or competitors for real laboratories, but rather as opportunities to bridge the gaps found in real laboratories where experiments are too expensive (either the cost of instrumentation or supplies of materials), complex or even dangerous to perform. safely recreated in a virtual environment. In addition, the experimental time is significantly reduced and the routine procedures for processing experimental results are simpler (Bortnik et al., 2017). In the virtual laboratory, students can access and carry out experiments in the virtual space that has been programmed (Alkhaldi et al., 2016). The virtual laboratory was chosen because it is in accordance with Heinich et al. (2002) who describe some of the advantages of a virtual laboratory as a simulator, namely; relatively safe, relatively expansive and provide opportunities for students to explore. Furthermore, virtual laboratories can be used as a low-cost alternative solution to real laboratories (Liu et al., 2015).

One of the virtual laboratories was implements a virtual laboratory for learning the excretory system (Setiawan et al., 2015). In addition, previous study examining the effectiveness of virtual laboratories to improve the competence and character of vocational students concluded that learning outcomes using virtual labs were better, especially in the implementation of practical activities that brought together the increased need for cognitive skills of students and made participants students understand an abstract and complex (Jaya et al., 2016). In addition, virtual laboratory practicum media can facilitate character education of vocational high school students in terms of being trustworthy, respecting others, being individually and socially responsible, fair, caring, and able to work together. In line with this, a previous study developed several 3D laboratories in a virtual environment for the Faculty of Engineering, University of Madrid (Fernández-avilés et al., 2016). The virtual laboratory developed is electro, chemical, physical, and topography using the OpenSim platform. A virtual laboratory is a necessity because it allows the carrying out of a difficult and dangerous experimental process if it is carried out in a real laboratory. In Indonesia, there are a study developed media in the form of a virtual laboratory on Biotechnology material for Class XII students using the 4D model development method (define, design, development, disseminate) (Amelia et al., 2018). The results of this development indicate that the virtual laboratory is effective as a learning medium, effective in terms of increasing learning motivation, completeness of students above KKM, affective students show interest, and good in the aspects of student psychomotor development.

The development of a virtual laboratory as a media for learning biology on the topic of plant tissue culture was also carried out by the previous study (Hartini et al., 2019). The product developed is intended for class XII MIA (Mathematics and Natural Science) students. This development research uses a 4D-model design and is considered to be able to improve the learning outcomes of class XII MIA high school students. There are study that examined virtual laboratories in education in the fields of science, technology, and engineering which were considered relatively lagging behind for distance learning (Potkonjak et al., 2016). The reason is because this field often requires practicum in the laboratory to provide effective skills and hands-on acquisition. The research, which focuses on the field of robotics, provides a critical review of existing concepts and technologies in the software-based virtual laboratory field, to identify current trends, and to contribute a solid foundation for future research. The development of virtual laboratories for science, technology and engineering supports more constructive and collaborative learning activities. Students who were surveyed about satisfaction and perceptions about usability and learning in practical (virtual) laboratories and computer-based (virtual) practices in various natural sciences felt the students' online laboratory experiences were equal to or better than previous

experiences in traditional environments. Survey data also shows that students believe laboratory experiences strengthen and enhance students' understanding of the concepts presented in lectures and textbooks, and hence may have helped them perform better in the learning process (Rowe et al., 2017).

The results of observations show that the benefits of using a virtual laboratory are that it can be accessed from a remote location and is available at any time, is flexible so that students can repeat the experiment anytime and anywhere, the cost is cheaper, it is safe because students are protected from dangerous materials, and it is possible to to carry out new simulations and experiments that are impossible in a real laboratory (Alkhaldi et al., 2016). Based on previous research studies, virtual laboratories are effective as learning media and can increase student motivation. Virtual laboratories can also facilitate learning, because they allow the carrying out of a difficult and dangerous experimental process if it is carried out in a real laboratory. Thus, it is assumed that development research on virtual laboratories will improve the skills of students before entering the real laboratory. Virtual systems will allow learners to perform repeated experiments, which they may not be able to do in real life. In this way these systems can form an important part of a traditional laboratory. but it does not appear to replace actual laboratory work. The virtual laboratory has improved the safety and quality of the results developed. Virtual laboratories are also used to conduct experiments that are currently impractical. With the right development, it is hoped that the virtual laboratory can become one of the learning media that facilitates practical learning in vocational schools so that students can learn to prepare themselves during the pandemic period before practicing in the real laboratory. This study aims to conduct a need analysis for the development of a virtual laboratory. Needs analysis is carried out to gather data about gaps and needs as well profiles of students that can be used as a basis or reference in developing virtual laboratory at the next stage.

2. METHODS

The development of this virtual laboratory is based on a product-oriented learning development approach and uses a model development of William W. Lee and Diana L. Owens (Sugiyono, 2012). The needs analysis stage consists of a needs assessment and a front-end analysis as shown in Figure 1.

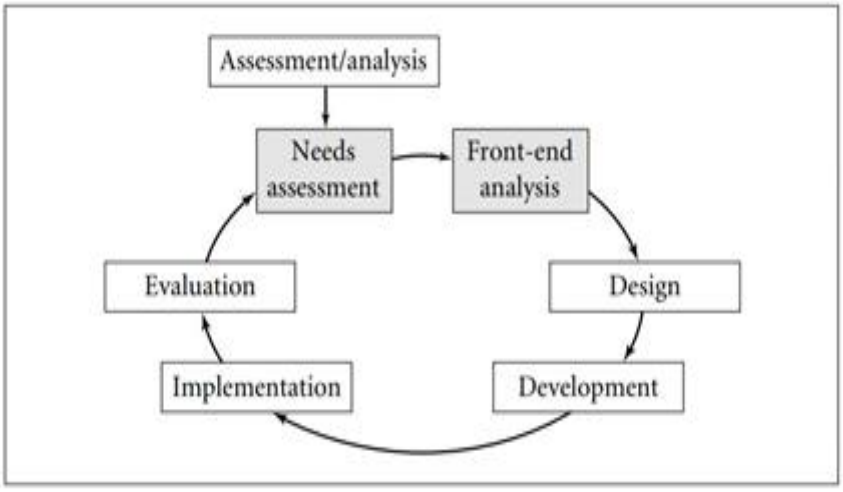

Figure 1. Lee-Owens Model Development Procedure

The first stage is the needs assessment stage. The needs assessment focuses on determining the current and desired state and the types of problems that arise. In the first stage, an assessment or analysis will be carried out in the form of a needs assessment. This needs assessment stage will determine whether there is a gap between the desired and current conditions. If there are gaps, the next step is to conduct a front-end analysis to then determine the type of intervention needed to close the gaps. This research is descriptive research. Data collection was carried out by observing, interviewing, and distributing questionnaires. The needs assessment is carried out by conducting direct interviews, distributing questionnaires to students, and observing. The purpose of this assessment is to determine the gap between the real conditions and the desired conditions. Interview with the teacher to obtain data on how the practical learning process has been, what obstacles are faced in this practical learning and to find out the media needs expected by the teacher. Questionnaires for students were carried out to obtain data on how nursery and tissue culture learning so far and how to use tissue culture laboratories. Observations

were made to obtain a real picture of the condition of the plant tissue culture laboratory at SMKN 63 Jakarta and to determine the computer laboratory facilities used.

3. RESULT AND DISCUSSION

Results

This study was a preliminary study for the development of a virtual plant tissue culture laboratory. Needs assessment is the first stage of Lee-Owen model. Stages in the Lee-Owen model are assessment/analysis, design, development, implementation, and evaluation. Needs assessment is carried out by conducting direct interviews. The results of interviews conducted with teachers at SMKN 63 found that the obstacles in learning the nursery and plant tissue culture were limited space and the lack of availability of tools and materials. To overcome these obstacles, the teacher divides students into groups to take turns following practicum. The conclusion of the interview results is shown in the Table 1.

Table 1. The results of interviews with the teacher

Questions	Answers
What are the obstacles in learning nursery and plant tissue culture?	Lack of availability of tools and materials as well as inadequate laboratory conditions. Furthermore, the constraint in learning tissue culture is the limited space because in practice the inoculation room cannot be filled by many people to avoid contamination, whereas in 1 class it usually consists of 35 people.
How to overcome these obstacles?	Maximizing available tools and materials and using substitute tools and materials that can be used Teacher also divide students into several groups.
What is needed to improve the quality of the learning process for Nursery and Plant Tissue Culture?	Improving room quality, tools and materials, LCD / Projector in the Lab, completing the needs of facilities and infrastructure, skilled laboratory assistants, teacher skills that must always be updated, trading teachers and laboratory assistants to the industry,

To obtain additional information about what will be developed, the next step is to do a front-end analysis. This stage consists of 10 steps, namely student analysis, technology analysis, situation analysis, task analysis, important incident analysis, objective analysis, problem analysis, media analysis, analysis of existing data, and cost analysis. The initial-final analysis was carried out by distributing questionnaires and observations.

Audience Analysis

Audience analysis includes age of students, ownership of a smartphone, ownership of a laptop / computer, media that is often used in the learning process, and media that is frequently used by the teacher. The analysis is presented in Table 2.

Table 2. Analysis of students

Aspect	Questionnaire Results
Age	Average age 17-18 years
Smartphone ownership	100% own a smartphone
Ownership of a computer / laptop	78% own a computer / laptop
The process of learning tissue culture	55.6% rated the learning process as very interesting 44.4% rated the learning process as interesting
Media that is often used by teachers in the learning process	88.3% exposure slide 5.6% modules 5.6% practicum
Preferred media format	16.7% video 83.3% combination of audio and video

Aspect	Questionnaire Results
The order of material that is often practiced	Sterilization of tools and materials Acclimatization Inoculation Isolate planting material
Information about virtual laboratories	77.8% knew
Willingness to download a virtual laboratory on a laptop / computer	94.4% are willing to download

Technology Analysis, The State Vocational High School (SMKN) 63 Jakarta is one of SMK taking computer-based national exam (UNBK). Therefore, SMKN 63 Jakarta has various facilities that can support the learning process using a virtual laboratory. The facilities provided are such as computer laboratories, projectors, and laptops owned by teachers and students. ***Situation Analysis,*** This analysis includes an analysis of the student's learning environment situation. Seen in terms of geographic location, SMKN 63 Jakarta is located in a strategic place for the Vocational School for Agribusiness and Agrotechnology Expertise. SMKN 63 Jakarta is also designated as a SMK Center of Excellent in 2020 for the fields of Agribusiness and Agrotechnology so that SMKN 63 is considered worthy as a place for testing the virtual laboratory being developed. ***Task Analysis,*** Task analysis is a procedure for tasks that need to be mastered by students regarding learning material. The tasks given during the offline meeting are laboratory room sterilization practicum, tool sterilization, media manufacture, inukolation and acclimatization. In the learning from home, the assignment carried out was analyzing instructional videos about tissue culture. ***Critical Analysis,*** The virtual laboratory being developed was originally planned to be used for the preparation of students before entering the real laboratory. However, with the COVID-19 pandemic, a virtual laboratory is needed to support the principles of Education Policy during the COVID-19 Pandemic. It is hoped that with the use of this virtual laboratory, students can reduce face-to-face practical learning time so that the risk of transmission during practical learning can be reduced.

Objective Analysis, The purpose of developing this virtual laboratory is to prepare students before entering the real laboratory so that practical learning time can be more effective, use of materials becomes efficient, and the risk of COVID-19 transmission can be reduced. ***Problem Analysis.*** Based on the student analysis questionnaire, the expectations of the virtual laboratory being developed are: The expected laboratory is a laboratory that can provide attractive and interactive learning; Has the availability of tools and materials in accordance with the SOP; Easy to understand and in accordance with the given module; A virtual laboratory that has interesting information and animation with depictions like in a live laboratory so that viewers and readers can also understand it well; Have the same principle as the whole practice; A virtual laboratory in accordance with the original, so that students can easily understand and can adapt if students practice directly; It is still more effective to learn in the lab directly than having to be virtual, because virtual will not be as good as a live lab, and students will lack understanding because during learning they only use virtual media; More broadly in providing material in order to better understand the material provided; Covers all aspects learned, the same as the offline practicum when in the laboratory, letting students learn; Have a clear simulated exposure to tissue culture; Providing more complete facilities and infrastructure; A virtual laboratory with pictures of all the tools to support the plant tissue culture process, so that students are more familiar with these various tools; Have a clear simulated exposure to tissue culture; Which contains material and a complete practical discussion; Providing videos in the practicum and the delivery is more interesting and easy to understand; A learning system that can be easily understood; Easy to understand.

Media analysis, Based on the previous stages of analysis, the media needed is media that can show attractive and interactive learning, has interesting information and animation with depictions like in a live laboratory, is in accordance with the original, and has a clear simulation of tissue culture. ***Extend-Data Analysis,*** Based on the results of interviews, observations, and questionnaires, it is known that a virtual laboratory is needed to be developed to show attractive and interactive learning, have interesting information and animations with depictions such as in a live laboratory, and have simulations. ***Cost Analysis,*** This analysis is needed to measure the high costs involved in making learning media. At this stage of the cost analysis includes the activities of determining costs, using costs and recording the final results of costs. The method used is to calculate design costs, development costs, implementation costs, and evaluation costs. The final results of the virtual laboratory will be posted on the psmk.kemdikbud.go.id page as a form of institutionalization so that the laboratory can be accessed by all vocational students for free.

Discussion

Based on the results of observation, interviews with teachers and student questionnaires, virtual laboratory development requirements are shown in the Table 3.

Table 3. Gap and need analysis

Gap	Need Analysis
Learning in SMK is mostly practice-based so that BDR activities cannot be fully implemented in pandemic Covid-19	Practicum is arranged in such a way so that practicum hours are more effective
Lack of availability of tools and materials as well as inadequate laboratory conditions. Furthermore, the constraint in learning tissue culture is the limited space	Learning media is needed to simulate tools and materials
Time of practicum is shorter	Learning media is needed so the student can learn to prepare themselves before entering the real laboratory so that face-to-face time for practicum can be reduced

Analysis that can be done based on the gap above is learning media is needed for facilitating learning practices. Front-end analysis show that the media needed is media that can show attractive and interactive learning, has interesting information and animation with depictions like in a live laboratory, is in accordance with the original, and has a clear simulation of tissue culture. These needs are answered with Virtual Laboratory. An analysis of the need for a virtual laboratory was also obtained from previous research (Rowe et al., 2017). Students who were surveyed about satisfaction and perceptions about usability and learning in practical (virtual) laboratories and computer-based (virtual) practices in various natural sciences felt the students' online laboratory experiences were equal or better than previous experiences in traditional environments. Survey data also shows that learners believe laboratory experiences strengthen and enhance learners' understanding of the concepts presented in lectures and textbooks, and hence may have helped them perform better in the learning process (Rowe et al., 2017). In line with this, researchers also conducted literature studies to identify the use of virtual laboratories for vocational students. Based on the literature study, it is known that the development of virtual laboratories for SMK is still small. The use of virtual laboratories for SMK is more for non-vocational subjects. Whereas virtual systems allow students to perform repeated experiments, which they may not be able to do in real life.

Educational institutions, in this case SMK, will benefit from better accessibility to virtual technology as it allows learning in virtual environments that are impossible to visualize in physical classrooms, such as access to virtual laboratories, visualization machines, industrial plants. Most likely, accessible virtual technology will make it possible to break through the boundaries of formal education (Martín-Gutiérrez et al., 2017). This is very good for improving the skills of students in SMK. Besides having advantages, virtual laboratories also have disadvantages. After practicing with a virtual laboratory, students become more confident in operating equipment in a real laboratory (Dyrberg et al., 2017) but other study note that simulation only functions as a tool for preparation and not as a substitute for a physical laboratory because it cannot provide the same touch experience and information as in a laboratory physical. In addition, simulations in particular have been shown to be effective for learning when adequate guidance is provided (Makransky et al., 2019) .

Based on the research results, the virtual laboratory can be developed further. The expectations of students and teachers can be used as the basis for designing and developing virtual laboratory products. Adjustment of the four ministerial decree related to learning during the Covid-19 pandemic where SMKs are allowed to carry out face-to-face practical learning with strict health protocols can be an impetus for developing a virtual laboratory for SMK. This virtual laboratory development can also be devoted to vocational subjects. With the virtual laboratory, students can learn to prepare themselves before entering the real laboratory so that face-to-face time for practicum can be reduced and there is direct interaction between students and between students and teachers. This is expected to reduce the possibility of Covid-19 transmission during face-to-face practical learning.

4. CONCLUSION

Virtual labs are not meant to replace real laboratories. During the Covid-19 pandemic, this virtual laboratory could be used to help students prepare themselves before entering the real laboratory. Learning Technology Developers at the SMK Directorate can design virtual laboratories for practical learning of vocational subjects. With the right development, it is hoped that virtual laboratories can become new opportunities that are not realized in real laboratories at affordable costs to produce vocational graduates who are skilled and still fulfill learning principles during the Covid-19 pandemic.

5. ACKNOWLEDGMENTS

This research and development is funded by Excellence Scholarship Program (Program Beasiswa Unggulan) from the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia

6. REFERENCES

Abidah, A., Hidaayatullaah, H., Simamora, R., Fehabutar, D., & Mutakinati, L. (2020). The Impact of Covid-19 to Indonesian Education and Its Relation to the Philosophy of "Merdeka Belajar." *Studies in Philosophy of Science and Education*, *1*(1), 38–49. https://doi.org/10.46627/sipose.v1i1.9.

Aljuhani, K., Sonbul, M., Althabiti, M., & Meccawy, M. (2018). Creating a Virtual Science Lab (VSL): the adoption of virtual labs in Saudi schools. *Smart Learning Environments*, *5*(1). https://doi.org/10.1186/s40561-018-0067-9.

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.

Amelia, T., Razak, A., & Rusdinal. (2018). Pengembangan Media Virtual Laboratory Pada Materi Bioteknologi untuk Siswa Kelas XII SMA. *ResearchGate*, *August*.

Astuti, I. Y., & Harun, H. (2020). Tantangan Guru dan Orang Tua dalam Kegiatan Belajar Dari Rumah Anak Usia Dini pada Masa Pandemi Covid-19. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini*, *5*(2), 1454–1463. https://doi.org/10.31004/obsesi.v5i2.808.

Bortnik, B., Stozhko, N., Pervukhina, I., Tchernysheva, A., & Belysheva, G. (2017). Effect of virtual analytical chemistry laboratory on enhancing student research skills and practices. *Research in Learning Technology*, *25*. https://doi.org/10.25304/rlt.v25.1968.

Brinson, J. R. (2015). Learning outcome achievement in non-traditional (virtual and remote) versus traditional (hands-on) laboratories: A review of the empirical research. *Computers and Education*, *87*, 218–237. https://doi.org/10.1016/j.compedu.2015.07.003.

Dyrberg, N. R., Treusch, A. H., & Wiegand, C. (2017). Virtual laboratories in science education: students' motivation and experiences in two tertiary biology courses. *Journal of Biological Education*, *51*(4), 358–374. https://doi.org/10.1080/00219266.2016.1257498.

Fernández-avilés, D., Dotor, D., Contreras, D., & Salazar, J. C. (2016). Virtual labs: a new tool in the Education. *13th International Conference on Remote Engineering and Virtual Instrumentation (REV)*, *February*, 271–272. https://ieeexplore.ieee.org/abstract/document/7444480.

Hartini, N., Erlia, & Iqbal, M. (2019). Pengembangan Virtual Laboratory pada topik kultur jaringan tumbuhan untuk meningkatkan hasil belajar siswa. *JIPVA (Jurnal Pendidikan IPA Veteran)*, *3*(1), 1–16. https://doi.org/10.31331/jipva.v3i1.658.

Heinich, R., Molenda, M., Russell, J. D., & Smaldino, S. E. (2002). *Instructional Media and Technologies for Learning*. Merrill Prentice Hall.

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.

Kurniasari, A., Pribowo, F. S. P., & Putra, D. A. (2020). Analisis efektivitas pelaksanaan belajar dari rumah (BDR) selama pandemi Covid-19. *Jurnal Review Pendidikan Dasar: Jurnal Kajian Pendidikan Dan Hasil Penelitian*, *6*(3), 246–253. https://doi.org/10.26740/jrpd.v6n3.p246-253.

Liu, D., Valdiviezo-díaz, P., Riofrio, G., & Sun, Y. (2015). Integration of Virtual Labs into Science E-learning. *Procedia - Procedia Computer Science*, *75*(Vare), 95–102. https://doi.org/10.1016/j.procs.2015.12.224.

Makransky, G., Mayer, R. E., Veitch, N., Hood, M., Christensen, K. B., & Gadegaard, H. (2019). Equivalence of using a desktop virtual reality science simulation at home and in class. *PLoS ONE*, *14*(4), 1–15. https://doi.org/10.1371/journal.pone.0214944.

Martín-Gutiérrez, J., Mora, C. E., Añorbe-Díaz, B., & González-Marrero, A. (2017). Virtual technologies trends in education. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(2), 469–486. https://doi.org/10.12973/eurasia.2017.00626a.

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.

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.

Rowe, R. J., Koban, L., Davidoff, A. J., Thompson, K. H., & Rowe, R. J. (2017). Efficacy of Online Laboratory Science Courses. *Journal of Formative Design in Learning*. https://doi.org/10.1007/s41686-017-0014-0.

Setiawan, H., Isnaeni, W., Budijantoro, F. P. M. H., & Marianti, A. (2015). Implementation Of Digital 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.

Sugiyono. (2012). *Metode Penelitian Pendidikan (Pendekatan Kuantitatif, Kualitatif dan R&D.* Alfabeta.

Yuzulia, I. (2021). The Challenges Of Online Learning During Pandemic : Students ' V oice. *Jurnal Bahasa Dan Sastra*, *13*(1), 8–12. https://doi.org/10.31294/w.v13i1.9759.