Jurnal Teknologi Pendidikan, April 2024, 26 (1), 171-182
DOI: http://dx.doi.org/10.21009/JTP2001.6
p-ISSN: 1411-2744 e-ISSN: 2620-3081
Accredited by Directorate General of Strengthening for Research and Development
Available online at http://journal.unj.ac.id/unj/index.php/jtp

Virtual Laboratory and Self-Efficacy in Optimizing Problem-Solving Skills: A Case in Applied Chemistry Learning in Vocational College

Arsani, Ida Ayu Anom[1(*)], Ida Bagus Putra Manuaba[2], I Ketut Darma[3], M.Yusuf[4]
[1,2,3,4] Politeknik Negeri Bali, Badung, Indonesia

Received : October 18, 2023
Revised : April 25, 2024
Accepted : April 28, 2024

Abstract
The limitation of laboratory facilities in conducting practical chemistry learning activities has become one of the triggers for less optimal learning processes. Implementation of virtual laboratory simulation becomes a solution to overcome the limited equipment of practicum activities. It is possible to overcome some of the challenges that are currently being experienced in chemistry education by making effective use of virtual laboratories. The primary aim of this research is to investigate the impact of virtual laboratories and self-efficacy on the improvement of problem-solving skills among engineering students in the context of applied chemistry education. The research employs a quasi-experimental design to examine the impact of independent variables on dependent variables. Participants in this study are students enrolled in the Refrigeration and Air Conditioning Engineering and Utility Engineering Technology programs within the Mechanical Engineering Department of Bali State Polytechnic. The study utilized data collection instruments consisting of tests assessing problem-solving skills and questionnaires measuring self-efficacy. The current study employs analysis of covariance (ANCOVA) as a statistical method to examine the hypothesis.The hypothesis testing results show that using virtual laboratories has a better effect than problem-solving skill demonstrations when it comes to electroplating learning activities. The observed correlation between self-efficacy and improved problem-solving skills does not seem to result in a significant impact.

Keywords: virtual laboratory, selft-efficacy, problem-solving skills

(*) Corresponding Author: ayuanomarsani@pnb.ac.id

How to Cite: Ida Ayu Anom, A., Ida Bagus Putra Manuaba, I Ketut, D., & M, Y. (2024). Virtual Laboratory and Self-Efficacy in Optimizing Problem-Solving Skills: A Case in Applied Chemistry Learning in Vocational College . *JTP - Jurnal Teknologi Pendidikan*, *26*(1), 171-182. https://doi.org/10.21009/jtp.v26i1.39559

INTRODUCTION

Having knowledge of today's multidisciplinary science is essential to supporting the skills and competencies that engineers possess to deal with complex global problems. This qualification becomes a demand for mechanical engineering students in vocational higher education to understand the basic science related to the competence of the field of science possessed by the vocation so that they can compete in the world of industry and work. A good conceptual understanding of basic sciences, such as chemistry, plays an important role in supporting the development of competence in the field of mechanical engineering, so it is essential to optimize learning activities in the classroom as well as in the laboratory. A laboratory is a place for conducting scientific research where a student can develop

CC BY SA

scientific thinking, conduct scientific research, and acquire knowledge of the principles of physics and experimental techniques through the use of equipment. Science laboratories are designed for a specific purpose, which includes an understanding of scientific concepts, interests, and motivations, practical skills, and problem-solving skills.

A laboratory serves as a dedicated space for the purpose of conducting scientific research, enabling students to cultivate their scientific reasoning, engage in scientific investigations, and gain comprehension of the fundamental principles of physics and experimental methodologies by utilizing specialized equipment. Science laboratories are purposefully constructed to facilitate the acquisition of scientific knowledge, comprehension of scientific principles, cultivation of scientific curiosity, development of practical abilities, and enhancement of problem-solving aptitude. Learning science, technology, engineering, and math requires laboratory practice. Virtual labs offer safe practice without worrying about equipment damage and give students the freedom to practice as much as they want without being time-restricted.Learning activities in laboratories are one of the identities of teaching chemistry to conduct scientific experiments through scientific approaches and skill development. The availability of laboratories in chemical learning is also an important component in explaining the application of chemical concepts to the field of mechanical engineering to serve as a reference in solving field problems related to chemistry, but most educational institutions have limited laboratory facilities.

The limitation of laboratory facilities becomes an obstacle to conducting chemical practice activities, so it requires a learning medium to facilitate practice activities. The digital age today offers many solutions and innovations in various forms of learning media applications that can facilitate practical activities, such as virtual laboratories that can be accessed through an internet connection. Virtual laboratories can be used as learning media to support practical activities in an effort to improve student learning outcomes and as a solution to the limitations of laboratory facilities. The use of virtual labs can help students prepare themselves before entering a real laboratory and improve their knowledge, skills, and learning performance. Virtual applications in learning refer to the use of technology to create a simulated and interactive learning environment that positively impacts students' understanding and improves learning outcomes (Annis Kandriasari et al., 2023; Sukmawati et al., 2023; Jusuf et al., 2021; Aulia et al., 2021; Durukan et al., 2020).

Virtual experiments provide flexible learning opportunities that can overcome time, speed, and space barriers for students (El Kharki et al., 2021; Hamed & Aljanazrah, 2020; Bortnik et al., 2017) The implementation of virtual laboratories contributes to increased motivation and effectiveness for learning activities (Santos & Prudente, 2022; Gunawan et al., 2019). The advantages of a virtual laboratory are that it is easy to use, easy to understand theoretical concepts, plenty of time available, satisfactory knowledge theory, a secure environment, advancement of new expertise, driven by group collaboration, a comfortable place, and more time to experiment (Emda, 2017). A virtual laboratory serves as a medium used to motivate students to understand a material concept and become a solution for overcoming the limitations or absence of a laboratory device. A virtual chemical laboratory is a simulation of chemical experiments that serves to address the limitations of the availability of tools and materials in chemical laboratories and create opportunities to conduct experiments with cheap funding. Referring to some research findings, virtual laboratory applications in chemistry learning can improve learning outcomes (Rizal Ramadhan et al., 2022; Nais et al., 2019; Nais et al., 2018; Ramos et al., 2016; Kolil et al., 2020).

Learning outcomes describe skills, abilities, knowledge, or values that can be measured as a result of the learning process. Chemistry, as one of the courses considered difficult by most students with competences that are not linear with the field of chemistry, is likely to cause anxiety that can affect student self-efficacy and problem-solving skills related to the application of chemical concepts to the engineering field. Self-effectiveness refers to the individual's belief in the ability to solve problems with the best results in a particular task, as well as the main development factor of the individual in using the difficulties experienced. Self-efficacy is a key factor in completing a task successfully. In the field of education, self-efficacy is critical to producing behavioral changes that result in improved performance over the course of learning. Students in chemistry often acquire anxiety about completing experiments due to the perceived negative results of a lack of understanding and inappropriate experimentation. Students' self-efficacy in doing laboratory experiments suffers as a result of their nervousness. Problem-solving skills refer to a person's ability to solve problems effectively and promptly without any obstacles. Problem-solving skills help in identifying the source of problems and finding effective solutions. Based on the above description, the implementation of virtual laboratory simulation can be an option as a medium for practice development activities due to the limited facilities of the laboratory on campus, as well as its impact on improved self-efficacy and student problem-solving skills.

Problem-solving is an important part of learning chemistry as a broadly transferable skill for engineering students to generalize what they have learned. The steps used to assess problem-solving skills are Polya's model , which consists of four steps of solution, namely: (1) To understand the problem, the learner must identify information, data availability, assumptions, and the desired solution at this stage. (2) develop a plan: at this stage, the student must attempt to link information and data in accordance with the intended solution; if this integration is not sufficiently evident, the student must develop a plan that outlines how to combine the available information with what is desired. (3) apply the plan: the student is expected to implement a planned approach for issue solving; (4) glance backward at this phase; the dawn look back indicates rethinking and re-examining the results and the solution process. The level of self-efficacy that an individual possesses can vary across different domains of tension. The research aims to investigate the impact of the use of virtual laboratories and the level of self efficacy on student problem-solving skills on vocational higher education in the context of applied chemistry learning. The Virtual Laboratory aims to provide a more interactive and in-depth learning experience while assisting students in building confidence in their ability to tackle complex problems in the field of applied chemistry. The research innovation introduces a virtual laboratory designed to enhance self-efficacy in optimizing problem-solving skills, particularly within the context of applied chemistry learning in vocational colleges. Through this approach, students can gain practical experience in chemical experiments without the need for expensive or limited physical equipment. This claim is supported by several research findings that show the use of virtual laboratories and the development of self-efficacy have positive effects on learning outcomes and can be successfully implemented in the context of teaching chemistry(Chan et al., 2021; Peechapol, 2021).

The hypothesis of the research is that (1) there is a difference in problem-solving skills between those learning with a virtual laboratory and a real demonstration; (2) there are differences in troubleshooting skills with different levels of self-efficacy; and (3) there is an interaction between virtual labs and real demonstrations and a different level of self-efficacy versus problem-solving skills.The results of this research are expected to have important implications for the innovative findings of learning methods that can be applied in vocational colleges and strengthen the use of technology in the learning process.

METHODS

The study uses a quasi-experimental design to test the influence of independent variables on dependent variables. The independent variable in this study is the virtual laboratory, while the moderator variable is self-efficacy, and the dependent variable is problem-solving skills. Another factor that can influence the dependent variable is variable involvement, which was incorporated in this study through a 2 x 1 factorial design. Participants in the study consisted of 62 students from the study program of refrigeration and air conditioning engineering and utility engineering technology. Research subjects are parallel classes determined non-randomly, as experimental and control groups. The group experiments were conducted by utilizing a virtual laboratory that featured a simulation of the metal coating process using the electroplating method. The control group observed and studied the electroplating process through a live demonstration.

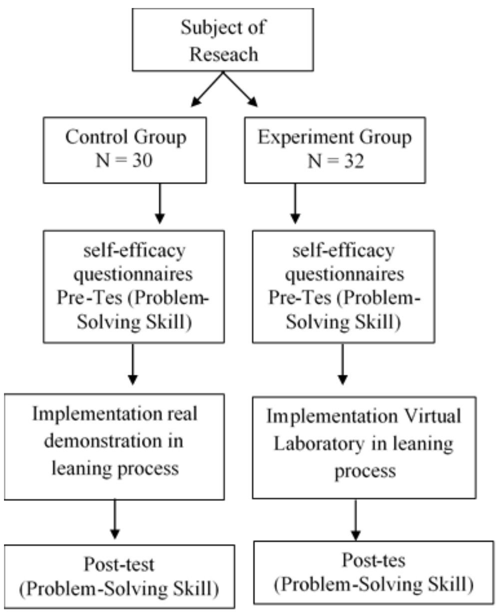

Figure 1. Outline of Research Design

The virtual laboratory simulation system encompasses several key components designed to facilitate the learning of chemistry in the context of electroplating materials. One such component is the inclusion of practical procedures and interactive 3D simulations. By incorporating these elements, the system enables students to engage in laboratory experiments by means of virtual simulations. 2) This instructional video demonstrates the practical application of electroplating techniques for coating metals. 3) An animated presentation is utilized to enhance the understanding of the electroplating.

RESULTS & DISCUSSION

The data collection instruments employed in this study encompass problem-solving skills tests and self-efficacy questionnaires. The primary objective of data analysis is to derive significance and interpretation from the data acquired subsequent to the process of learning. Using analysis of covariance (ANCOVA) to test the hypothesis in this research with the assistance of the SPSS version 22 application.

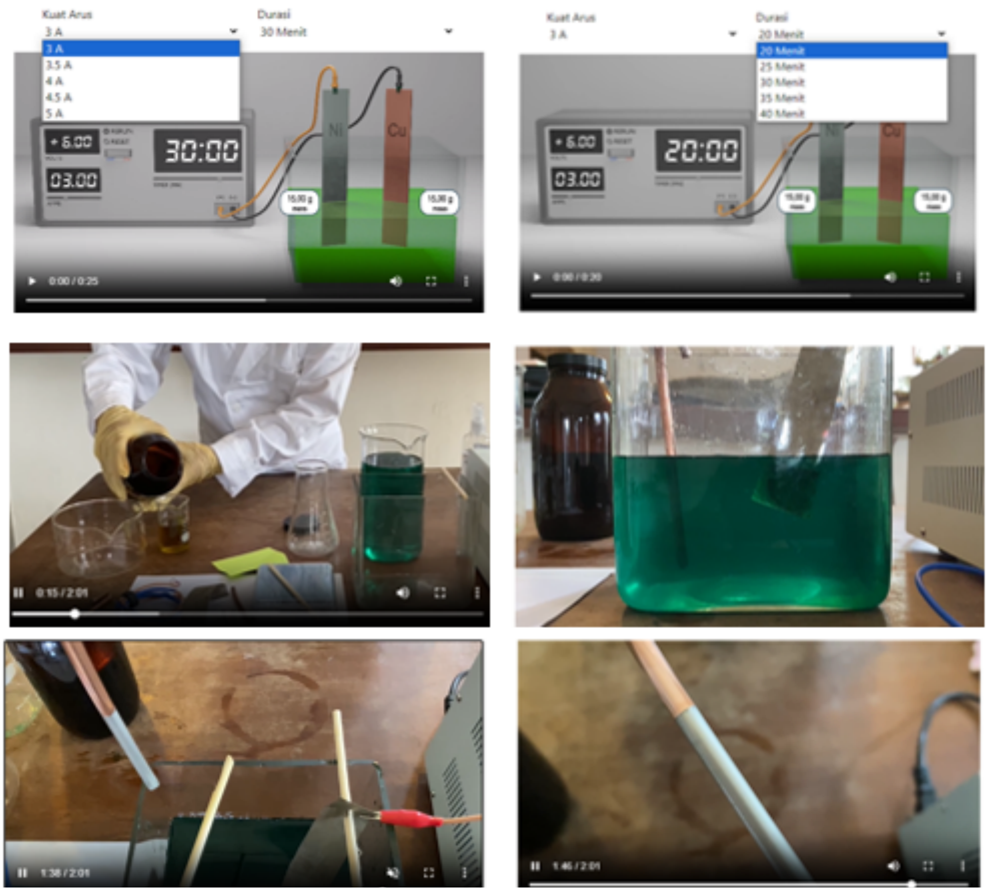

Figure 2. Features Virtual Laboratory Electroplating

Table 1. Rubric for Assessing Problem-Solving Skills (Thi Dang Chi & Trung Ninh, 2018)

No	Steps Model	Problem-Solving Skill Criteria (Score) 0	1	2	3
1	Understanding the problem	No information or no images, no reaction equations or symbols used	There's little information, there's a picture, but no similarity of reactions or symbols used	There's information, there's pictures, there are reaction equations, but it's only partially defined.	Appropriate information accompanied by images, reaction equations and defined.
2	Making Planning	There's no plan or no coherent plan to solve the problem.	Can develop an initial phase plan but only perform part of all the components of the plan.	Can develop a good plan but can't approach problems systematically.	Can choose a good strategy and approach the problem systematically. No conceptual errors.
3	Planning Implementation	A limited number of jobs are displayed. The calculation equation is completely wrong.	The job is partially displayed. The calculation contains major errors.	The work displayed has gaps. The reaction equations and calculations are mostly correct but may contain minor errors.	The work shown is logical. The equation of reaction and calculation is completely correct
4	Reviewing back	Wrong answer and no answer statemen	Can give an appropriate answer statement, even if the answer is wrong.	Get the right answers but can't give an appropriate statement of answers.	Can get the right answers and give the perfect answer statement.

RESULTS & DISCUSSION

The distribution of pre-test values for each group, if combined with the self-effectiveness of the student, does not show an extreme difference in average values between the groups of students with low self-efficacy and high self-efficacy. Students with hight self-efficacy scored 28.55 in the control group and 31.23 in the high self-efficacy, whereas in the experimental group, they obtained scores of 29.56 and 32.45 for low self-efficacy and high self-efficacy, as shown in Table 2.

Tabel 2. Descriptive Analysis Pre-test and Post-test Problem-Solving Skills and Self-Efficacy

Groups	Self-Efficacy (SE)	Pre-test			Post-Test		
		Mean	SD	n	Mean	SD	n
Control	SE_Hight	28.55	3.53	7	50.89	11.21	7
	SE_Low	31.23	8.69	23	60.23	9.12	23
	Total	30.61	7.83	30	58.05	10.26	30
Experiment	SE_Hight	32.45	9.53	12	69.57	13.23	12
	SE_Low	29.56	6.52	20	71.02	8.70	20
	Total	30.65	7.76	32	70.48	10.44	32
Total	SE_Hight	31.01	7.96	19	62.68	15.31	19
	SE_Low	30.45	7.72	43	65.25	10.36	43
	Total	30.62	7.73	62	64.46	12.02	62

According to the data presented in Table 2, the experimental group achieved higher mean scores on the post-test when compared to the control group. In relation to self-efficacy, it is observed that students with lower levels of self-efficacy tend to exhibit a higher likelihood of experiencing certain outcomes compared to students with higher levels of self-efficacy.

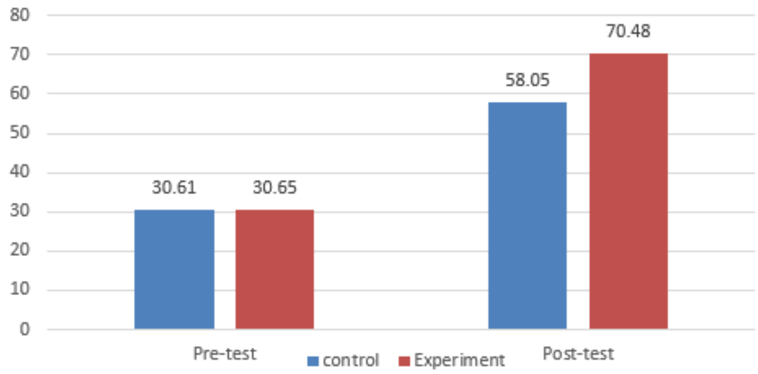

Figure 3. Average Pre-Test and PostTest Values for Problem Solving Skills

The observed results showed variations in the pre-test and post-test averages between the control and experimental groups. The experimental group's average values showed higher averages than the controlgroup, as shown in Figure 3. In relation to student self-efficacy, there is no significant difference observed between high and low self-efficacy when compared to the average values obtained in both the control and experimental groups, as depicted in Figure 4.

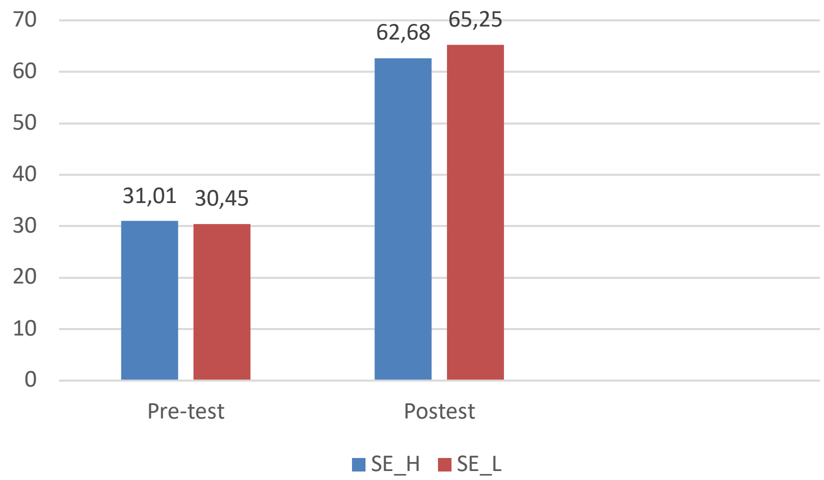

Figure 4. Comparison of Pre-Test and Post-Test Results in Relation to Self-Efficacy

The inter-variable influence test is a primary method employed to evaluate the null hypothesis. The test results against the hypothesis of this study showed: (1) the significance value on the post-test of problem-solving skills is 0.00, which means less than 0.05. This result indicates that the null hypotheses are rejected or that there is a significant difference in problem-solving skills between groups of students who received different treatment in the learning process, (2) The second null hypothesis tested was that there was no difference in problem-solving skills between groups of students with self-efficacy. The test results showed that the significance value obtained was 0.64, or greater than 0.05. This result meant that the null second hypothesis was accepted or that there were no significant differences in troubleshooting skills among groups of students with self-efficacy, (3) The obtained significance value is 0.174, or greater than 0.05. This value has an influence on the outcome of the third accepted null hypothesis, which means that there is no interaction between the treatment of the use of virtual laboratory simulations and real demonstrations and self-efficacy toward problem-solving skills.

Table 3. Tests of Between-Subjects Effects

Source	Dependent Variable (Problem-Solving Skill)	F	p
Corrected Model	post-test	9.339	0.00
Method (Demonstration & Vir.Lab)	post-test	26.474	0.00
Self_Efficacy	post-test	3.556	0.064
Method * Self_Efficacy	post-test	1.894	0.174

The skill of problem-solving is associated with the ability to resolve a problem involving critical, logical, and systematic thinking, which is one of the significant objectives of the implemented learning process. Referring to the results of the hypothesis testing, the use of virtual laboratories has a more positive impact than demonstrations of problem-solving skills on learning activities about electroplating. Virtual laboratories can facilitate the interpersonal development of learners by addressing individual differences in groups and improving problem-solving skills. One important skill that engineering students can use to generalize or build on what they have learned is problem-solving, which is an important part of learning chemistry (Lawrence S. Brown, 2019).

The results obtained, in conjunction with comparable findings from other studies, suggest a favorable influence of utilizing a virtual laboratory on educational achievements (Veza et al., 2022; Gunawan et al., 2017). According to study findings (Gunadi et al., 2023; Nais et al., 2019), students can learn more independently and overcome time and space constraints in the learning process by utilizing technology and readily available information.

These findings lend support to the implementation of the suggested learning environment in laboratory-based educational practices as a viable substitute for physical laboratories (Solikhin et al., 2022; Ahmed & Hasegawa, 2021). Virtual chemistry laboratories should be considered as an effective supplement to or replacement for conventional laboratories (Chan et al., 2021; Srinivasa et al., 2021; Gunawan et al., 2018; Ali et al., 2014).Virtual laboratories can provide better learning outcomes on cognitive, affective, and skill aspects than practice in real laboratories (Faruk et al., 2023; Chan et al., 2021; Huang et al., 2020). When combined with self-efficiency, it gives insignificant results to problem-solving skills. These results differ from the research that has been done that self-effectiveness improves learning outcomes (Gungor et al., 2022; Romika & Atun, 2021). The results of this research provide significant implications for changes in learning methods applicable to vocational college, particularly in the domain of applied chemistry. The presence of a virtual laboratory aids students in cultivating confidence in their capacity to tackle intricate challenges within applied chemistry. These research contributions have the potential to enhance students' problem-solving skills in applying chemical concepts in the field of engineering and offer solutions to the limited equipment and laboratory facilities in chemistry learning.

CONCLUSION

Based on the results and explanations provided, this study concludes that there is a difference in problem-solving skills between the control group students and the experiment., while no disparities were found in problem-solving skills among student groups with varying self-efficacy levels. Additionally, there was no observed interaction between the applied method and the self-efficacy of problem-solving skills. It is suggested that virtual laboratories could serve as either supplementary tools or replacements for physical labs, especially in instances where the latter is unavailable. Further research is recommended to explore the relationship between virtual chemistry laboratories and self-efficacy in problem-solving skills among mechanical engineering students.

ACKNOWLEDGEMENT

This research is funded by the Bali State Polytechnic through DIPA PNB 2023

REFERENCES

Ahmed, M. E., & Hasegawa, S. (2021). Development of online virtual laboratory platform for supporting real laboratory experiments in multi domains. *Education Sciences*, *11*(9). https://doi.org/10.3390/educsci11090548

Ali, N., Ullah, S., Alam, A., & Rafique, J. (2014). 3D interactive virtual chemistry laboratory for simulation of high school experiments. *Proceedings of Eurasia Graphics*, *November 2015*, 1–6.

Annis Kandriasari, Yeni Yulianti, Rina Febriana, & Mohd Nordin, R. (2023). Development Of Practicum Learning Models Assisted with Practice Guide Videos. *JTP - Jurnal Teknologi Pendidikan*, *25*(2), 246–256. https://doi.org/10.21009/jtp.v25i2.34678

Aulia, N. R., Supriana, E., Latifah, E., & Suprapto, A. (2021). Improving Students ' Understanding on Static Fluids Using Virtual Laboratory During Covid-19 Pandemic. *Jurnal Pendidikan Sains*, *9*(4), 104–108.

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

Chan, P., Van Gerven, T., Dubois, J.-L., & Bernaerts, K. (2021). Virtual chemical laboratories: A systematic literature review of research, technologies and instructional design. *Computers and Education Open*, *2*, 100053. https://doi.org/10.1016/j.caeo.2021.100053

Durukan, A., Artun, H., & Temur, A. (2020). Virtual Reality in Science Education: a Descriptive Review. *Journal of Science Learning*, *3*(3), 132–142. https://doi.org/10.17509/jsl.v3i3.21906

El Kharki, K., Berrada, K., & Burgos, D. (2021). Design and implementation of a virtual laboratory for physics subjects in moroccan universities. *Sustainability (Switzerland)*, *13*(7). https://doi.org/10.3390/su13073711

Emda, A. (2017). Laboratorium Sebagai Sarana Pembelajaran Kimia Dalam Meningkatkan Pengetahuan Dan Ketrampilan Kerja Ilmiah. *Lantanida Journal*, *5*(1), 83. https://doi.org/10.22373/lj.v5i1.2061

Faruk, M., M, I. M. S. U., Syafi'i, I., Mukhidin, Sukirman, D., Ali, M., & Alias, N. (2023). *The Role of Using Virtual Reality in Learning in an Education Environment* (Vol. 1). Atlantis Press SARL. https://doi.org/10.2991/978-2-494069-35-0_148

Gunadi, R. A. A., Efendi, Y., Muflihin, M. H., & Isroani, F. (2023). *E-Learning as A Learning Medium in The Digital Era of the 21st Century*. *25*(April), 159–166.

Gunawan, G., Harjono, A., Sahidu, H., Herayanti, L., Suranti, N. M. Y., & Yahya, F. (2019). Using Virtual Laboratory to Improve Pre-service Physics Teachers' Creativity and Problem-Solving Skills on Thermodynamics Concept. *Journal of Physics: Conference Series*, *1280*(5). https://doi.org/10.1088/1742-6596/1280/5/052038

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).

https://doi.org/10.1088/1742-6596/1108/1/012049
Gunawan, Harjono, A., Sahidu, H., & Herayanti, L. (2017). Virtual laboratory to improve students' problem-solving skills on electricity concept. *Jurnal Pendidikan IPA Indonesia*, *6*(2), 257–264. https://doi.org/10.15294/jpii.v6i2.9481
Gungor, A., Kool, D., Lee, M., Avraamidou, L., Eisink, N., Albada, B., van der Kolk, K., Tromp, M., & Bitter, J. H. (2022). The Use of Virtual Reality in A Chemistry Lab and Its Impact on Students' SelfEfficacy, Interest, Self-Concept and Laboratory Anxiety. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(3). https://doi.org/10.29333/ejmste/11814
Hamed, G., & Aljanazrah, A. (2020). THE EFFECTIVENESS OF USING VIRTUAL EXPERIMENTS ON STUDENTS' LEARNING IN THE GENERAL PHYSICS LAB. *Journal of Information Technology Education: Research*, *19*, 977–996. https://doi.org/10.28945/4668
Huang, C. L., Luo, Y. F., Yang, S. C., Lu, C. M., & Chen, A.-S. (2020). Influence of Students' Learning Style, Sense of Presence, and Cognitive Load on Learning Outcomes in an Immersive Virtual Reality Learning Environment. *Journal of Educational Computing Research*, *58*(3), 596–615. https://doi.org/10.1177/0735633119867422
Jusuf, H., Nurdin Ibrahim, & Atwi Suparman. (2021). Development of Virtual Learning Environment Using Canvas To Facilitate Online Learning. *JTP - Jurnal Teknologi Pendidikan*, *23*(2), 153–168. https://doi.org/10.21009/jtp.v23i2.22240
Kolil, V. K., Muthupalani, S., & Achuthan, K. (2020). Virtual experimental platforms in chemistry laboratory education and its impact on experimental self-efficacy. *International Journal of Educational Technology in Higher Education*, *17*(1). https://doi.org/10.1186/s41239-020-00204-3
Lawrence S. Brown, T. A. H. (2019). *Chemistry for Engineering Students, 4th Edition* (4th ed.). , Cengage Learning, Inc.
Nais, M. K., Sugiyarto, K. H., & Ikhsan, J. (2018). The profile of students' self-efficacy using virtual chem-lab in hybrid learning. *Journal of Physics: Conference Series*, *1097*(1). https://doi.org/10.1088/1742-6596/1097/1/012060
Nais, M. K., Sugiyarto, K. H., & Ikhsan, J. (2019). Virtual chemistry laboratory (virtual chem-lab): Potential experimental media in hybrid learning. *Journal of Physics: Conference Series*, *1156*(1). https://doi.org/10.1088/1742-6596/1156/1/012028
Peechapol, C. (2021). Investigating the Effect of Virtual Laboratory Simulation in Chemistry on Learning Achievement, Self-efficacy, and Learning Experience. In *International Journal of Emerging Technologies in Learning* (Vol. 16, Issue 20, pp. 196–207). https://doi.org/10.3991/ijet.v16i20.23561
Ramos, S., Pimentel, E. P., Marietto, M. D. G. B., & Botelho, W. T. (2016). Hands-on and virtual laboratories to undergraduate chemistry education: Toward a pedagogical integration. *Proceedings - Frontiers in Education Conference, FIE*. https://doi.org/10.1109/FIE.2016.7757580
Rizal Ramadhan, M., Najib Fahmi, M. I., & Mutiara Hasanah, S. (2022). Augmented Reality Visualization through Multirepresentations Approach in

Chemistry Based on Qur'anic to Improve Cognitive Learning Outcomes. *JTP - Jurnal Teknologi Pendidikan*, *24*(2), 197–211. https://doi.org/10.21009/jtp.v24i2.27097

Romika, Y., & Atun, S. (2021). Chemistry student's virtual laboratory self-efficacy: A scale development. *Journal of Physics: Conference Series*, *1806*(1). https://doi.org/10.1088/1742-6596/1806/1/012196

Santos, M. L., & Prudente, M. (2022). Effectiveness of virtual laboratories in science education: A meta-analysis. *International Journal of Information and Education Technology*, *12*(2), 150–156. https://doi.org/10.18178/ijiet.2022.12.2.1598

Solikhin, F., Sugiyarto, K. H., & Ikhsan, J. (2022). Using Virtual Laboratory: A Profile of Students' Self-Efficacy on Electrochemistry. *Acta Chimica Asiana*, *5*(1), 193–201. https://doi.org/10.29303/aca.v5i1.116

Sukmawati, F., Santosa, E. B., & Rejekiningsih, T. (2023). Virtual Reality-Based Learning about "Animals Recognition" and Its Influence on Students' Understanding. *JTP - Jurnal Teknologi Pendidikan*, *25*(2), 269–284. https://doi.org/10.21009/jtp.v25i2.36106

Veza, I., Sule, A., Putra, N. R., Idris, M., Ghazali, I., Irianto, Pendit, U. C., Mosliano, G., & Arasmatusy. (2022). Virtual Laboratory for Engineering Education: Review of Virtual Laboratory for Students Learning. *Engineering Science Letter*, *1*(02), 41–46. https://doi.org/10.56741/esl.v1i02.138