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Encyclopedia of Chemistry Laboratory Equipment to Support Basic Chemistry Practicum Learning

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Abstract

. These conditions can hinder the achievement of practicum objectives and potentially cause work accidents. This study aims to produce an Encyclopedia of Chemistry Laboratory Equipment to support Basic Chemistry Practicum Learning. This research is a Research and Development (R&D) with a 4-D development model. The method used to collect data is observation, interviews, and questionnaires. The instrument used to collect data is a test sheet. The data analysis technique used is descriptive qualitative, and quantitative analysis. The results of the research are expert judgments. The results show that the Encyclopedia of Basic Chemistry Laboratory Tools is valid in terms of content (3.86), language (3.94), media (3.86), and video (3.7) from a maximum score of 4. The readability test results of 9 students showed that all students gave a precise assessment. They clearly understand the information about laboratory equipment used as an entry in the Encyclopedia of chemical laboratory equipment. This study concludes that the Encyclopedia of Chemistry Laboratory Tools is feasible to implement the content, language, media, video, and readability to support learning Basic Chemistry Practicum.

Keywords: *Development, Encyclopedia, Laboratory Equipment, Basic Chemistry*

Introduction

Chemistry is a branch of science that has characteristics based on experiments. In studying chemistry, the practicum is needed as a hands-on learning experience to understand concepts and theories (Muchlis et al., 2020; Orimogunje, 2014). In carrying out practical activities in the laboratory, chemical laboratory equipment is needed. When students work in the laboratory, they must conduct experiments using various chemical laboratory equipment (Rasmawan, 2018; Wright et al., 2018). Knowledge and skills in using chemical laboratory equipment are important factors to support practicum activities (Su & Cheng, 2019; Zammiluni et al., 2018). In that case, it can result in errors in using tools and obtaining practicum results, resulting in practicum objectives not being achieved optimally (Herga, 2016; Tatli, 2010). In that case, it will prevent equipment damage and avoid accidents that can endanger the practitioner himself, others, and even the laboratory (Cahyaningrum et al, 2019).

The laboratory as a place for the implementation of practicum requires high sincerity. The teacher or lecturer's guidelines are important so that the students are doing the work well. They have to work with chemicals and various chemical equipment (Bortnik et al., 2017; Vysakh et al., 2020). The practical manual used by students as a guide for conducting experiments in the laboratory only contains the names of the laboratory equipment used. It does not provide information on the specifications, functions of these chemical tools and the use of them correctly. A laboratory is a place for teaching staff

(lecturers and teachers), students, and laboratory workers to conduct experiments with chemicals, glassware, and special tools (Walker et al., 2019; Wan Yunus & Mat Ali, 2018). Improper or unskilled use of chemical equipment is an unsafe behavior that can cause work accidents. Most work accidents in the laboratory are caused by unsafe behavior, the rest by unsafe conditions. According to the research results of the National Safety Council (NSC), the cause of work accidents is due to unsafe behavior (88%), unsafe conditions (10%), and the cause is unknown (2%) (Council, 2011). Another study also showed that work accidents were caused by unsafe behavior and unsafe conditions (Ma et al., 2022; Nasrallah et al., 2022). Based on these data, it can be concluded that work accidents are mainly caused by unsafe behavior, one of which comes from students' low knowledge and skills about laboratory equipment. Therefore, it is necessary to prevent work accidents in the laboratory due to students' lack of knowledge and skills about chemical laboratory equipment by providing an encyclopedia. Encyclopedias are one type of enrichment book, namely books that function to enrich students' knowledge, skills, and personality (Goldstein & DellaSala, 2022; Tockner & Mehner, 2022). Encyclopedias do not have a direct relationship with the applicable curriculum, so that the existence of this book can be maintained despite changes to the applicable curriculum.

Encyclopedias are a learning resource that provides basic and complete information about a problem (HCorke, 2016; Li et al., 2012). Encyclopedias can provide visualizations that attract students' interest in the learning process (Huang & Wang, 2017; Lin et al., 2014). Encyclopedias as learning resources can present knowledge broadly and contextually. Basic Chemistry is one of the courses programmed in the Chemistry Education Study Program, FMIPA Undiksha. The course is important because it is one of the basic sciences, so it is programmed first. Basic Chemistry is also very closely related and is a prerequisite for further chemistry, organic chemistry, physical chemistry, analytical chemistry, and biochemistry. Basic Chemistry course material is matriculative and aims to generalize students' initial knowledge and skills before taking advanced chemistry lectures. The material given in the Basic Chemistry lecture is the same as the chemistry material that students have obtained at the Senior High School level. Basic Chemistry is equipped with a practicum, where the topics practiced are aimed at strengthening the understanding and mastery of the concepts contained in the Basic Chemistry course.

Based on the experience of guiding students to carry out Basic Chemistry Practicum, students lack the skills to carry out practical work, including lack of skill in using chemical laboratory equipment. A preliminary study was conducted by interviewing colleagues who are lecturers in Basic Chemistry courses. It was found that the problems faced in implementing the Basic Chemistry Practicum were the lack of knowledge and skills of students about chemical laboratory equipment: names, uses, and how to use chemical laboratory equipment, which resulted which results in learning activities cannot run smoothly. The results of interviews conducted with first-year students to explore the causes of their low

knowledge and skills about chemical laboratory equipment were found out thatthey lacked of experience in conducting chemistry practicums while in high school. It is in line with the fact that many high schools cannot hold chemistry practicums according to the curriculum demands due to various reasons, such as limited tools and chemicals, and there are no laboratory assistants to help organize practicums.

As educational students (prospective teachers), students of the Chemistry Education Study Program need to master knowledge and skills about chemical laboratory equipment. Other research findings also state that students must master knowledge of laboratory equipment (Herga, 2016; Tatli, 2010; Vysakh et al., 2020). Other findings also state that knowledge of the use of laboratories is very important so that learning activities can run smoothly (Arista & Kuswanto, 2018; Bortnik et al., 2017; Walker et al., 2019). It is part of the competency standard for graduates to become professional chemistry teachers, including having the competence to manage practicum activities in the laboratory. Based on the above background, the research entitled "Development of an Encyclopedia of Chemistry Laboratory Tools to Support Basic Chemistry Practicum Learning" was conducted. This research aims to develop an Encyclopedia of Chemistry Laboratory Equipment to support Basic Chemistry Practicum Learning. The resulting encyclopedia is an enrichment textbook containing names, uses, and how to use chemical laboratory equipment. Especially for the use of laboratory equipment, besides being presented in writing textbooks, it is also presented in videos.

Methods

This is a Research and Development (R&D) using a 4-D development model, consisting of 4 stages: Define, Design, Develop, and Disseminate (Lukman et al., 2019). This research is limited on a small scale, including limiting research steps. The WFH (Work From Home) policy was implemented due to the COVID-19 pandemic on Undiksha. Practical activities are carried out from home. This research can only be done in three stages: Define, Design, and Develop. The development stage ends with a readability test. Practicality and effectiveness tests cannot be carried out because there is no practicum in the laboratory because of WFH Practicality tests and the need for using encyclopedia activities to support Basic Chemistry Practicum activities. The methods used to collect data are observation, interviews, and questionnaires. The instrument used to collect data is a test sheet. The technique used to analyze the data is descriptive qualitative, and quantitative analysis. Qualitative descriptive analysis was used to analyze data in expert input. Quantitative descriptive analysis is used to analyze the data in the form of expert scores.

Results And Discussion

Results

The results and discussion can be presented following the development procedure used in this development research, namely 4 D. In the define stage, a needs analysis is carried out through a preliminary study using interviews, observation, and document studies. Based on the preliminary study, it was found that the problems in the implementation of the Basic Chemistry Practicum were the low knowledge and skills of students in carrying out practicums. It caused the practicum cannot run smoothly, the practicum objectives were not achieved optimally, and it could cause work accidents in the laboratory. The low skills of first-year students (new students) in conducting chemistry practicums are due to their lack of experience in conducting chemistry practicums while in high school due to WFH (Work from Home) during the covid-19 pandemic.

As with other practical manuals, the main topics included are the title of the practicum, the theoretical basis, and work procedures. It is unusual for a practicum guide to contain knowledge about names, uses, and how to use chemical laboratory equipment. This manual only emphasizes work procedures and is not designed to provide information regarding knowledge and skills in using laboratory equipment. Students need to know the name of the tool, its use, and how to use the chemical laboratory equipment used in Basic Chemistry Practicum activities in the laboratory. By knowing the name of the tool, the use, and how to use the tool, students will be able to carry out Basic Chemistry Practicum smoothly, safely, or avoid work accidents and achieve practicum goals optimally.

From the concept analysis, it can be determined that the chemical laboratory tools that need to be included in the Encyclopedia of Chemistry Laboratory Tools to Support Basic Chemistry Learning, namely the tools related to the topics of Basic Chemistry Practicum I are separation and purification of substances, chemical reactions, determination of the relative atomic mass of Mg, determination of the formula of a hydrate, continuous variation and stoichiometry, thermochemistry, relative molecular mass determination of oxygen factors affecting the rate of reaction, and rate of reaction. Meanwhile, the topics for the Basic Chemistry II Practicum are effect of concentration on chemical equilibrium, freezing point depression of urea, acid-base titration, preparation and properties of colloids, electrolysis of KI solution, determination of the electromotive force of chemical cells, alkali and alkaline earth metals, halogen elements, and aldehydes and ketones. In addition to the analysis of the Syllabus for the Basic Chemistry I course. The Syllabus for the Basic Chemistry II course is also based on high school chemistry laboratory equipment analysis according to Permendikmas Nomor 24 Tahun 2007 concerning Standards for Facilities and Infrastructure for Elementary School, Junior and Senior High School.

Based on the basic chemistry practicum topics and Permendiknas Nomor 24 Tahun 2007 it can be identified 57 laboratory tools must be known by name, use, and how to use them, which are then

designated as entries or entries in the developed Encyclopedia. Of the 57 pieces of laboratory equipment, there are 19 glass instruments, 38 non-glass instruments. Design Stage. Based on the results obtained in the define stage, the initial design stage is carried out. The initial design intended is the Encyclopedia of Chemistry Laboratory Tools design, developed before being validated by experts and tested on students.

In design stage, media selection and format selection are carried out. The media used is an image media useful for clarifying entry information about laboratory equipment contained in the Encyclopedia. Students can know the names, uses, and how to use Basic Chemistry laboratory equipment correctly and safely. At this design stage, an encyclopedia book format was also chosen. The format chosen meets the criteria of being attractive, facilitating, and helping in learning (Pusat Perbukuan, 2007). The format or systematics of the Encyclopedia of Basic Chemistry Laboratory Tools is as follows cover, preface, instructions, table of contents, introduction, encyclopedia of basic chemistry laboratory tools, references and index. The presentation of the textbook is designed with a B5 paper size. The font used is Times New Roman 11 and Agency FB. The font in the textbook uses the Times New Roman in the description of the material. In contrast, the Agency FB font is used in the sub-chapter title so that the title looks contrasting compared to the description of the material. The material description is presented with 1.15 spaces. The development stage is divided into two activities, namely: expert appraisal and developmental testing. The expert appraisal is a technique for validating or assessing the feasibility of a product design. The Encyclopedia is assessed to cover aspects of content, language, and media. A summary of the results of validation by experts is presented in Table 1.

Table 1. Summary of Encyclopedia Validation Results

No.	Rated aspect	Average	Category
1	Content Validity	3.9	Valid
2	Language Validity	4.0	Valid
3	Media Validity	3.6	Valid

Table 1 shows that the experts rated it very feasible/valid on all aspects of product development, namely content aspects 3.9, language aspects 4.0, and media aspects (3.6) (from a maximum score of 4). Some suggestions for improvement from the experts include correcting typing errors (typo), improving the consistency of format and layout of presentation and image layout, and improving image quality. After making improvements according to the advice of the experts, the product development encyclopedia was declared feasible. Then a development test was carried out in the form of a readability test involving 9 students. The results of the readability test are presented in Table 2.

Table 2. Summary of Readability Test Results

No.	Rated aspect	Un-clear		Less Clear		Clear		Very Clear	
		n	%	n	%	n	%	n	%
1	The sentences used represent the information to be conveyed	0	0	0	0	2	22,2	7	77,8
2	The use of language does not cause double meaning	0	0	0	0	2	22,2	7	77,8
3	The words used are understandable (already familiar or familiar)	0	0	0	0	5	55,6	4	44,4
4	The images presented are informative and make it easier to understand	0	0	0	0	1	11,1	8	88,9
5	The description of how to use the tools presented is easy to understand	0	0	0	0	1	11,1	8	88,9
6	Systematic clarity of the contents/materials of the Encyclopedia of Basic Chemistry Laboratory Tools	0	0	0	0	3	33,3	6	66,7
7	Encyclopedia of Basic Chemistry Laboratory Tools helps facilitate the implementation of practicum	0	0	0	0	1	11,1	8	88,9

Table 2 shows that all students gave a clear or understood assessment until it was very clear or very understood about the names, uses, and how to use chemical laboratory tools presented in the Encyclopedia. Especially for how to use laboratory equipment, apart from being presented in writing in a book, it is also presented in a video. A summary of the results of expert validation of the video product developed is presented in Table 3. Based on Table 3 shows that the product development in the form of videos on how to use laboratory equipment is considered feasible or valid with a score of 3.7 (maximum score 4).

Table 3. Summary of Video Validation Results

No.	Rated aspect	Average	Category
1	Presentation Design	3.7	Valid
2	Audio-Visual Communication	3.6	Valid
3	Interaction Usability	3.7	Valid
4	Accessibility	3,8	Valid
5	Standard Compliance	3.5	Valid
Average		**3.7**	**Valid**

Discussion

Students will more easily understand the submission of information about using laboratory equipment if presented in videos. Learning videos will make it easier for students to understand the learning material presented in the video (Pamungkas et al., 2018; Putri et al., 2020; Rusmawan, 2013). It is in line with, illustrating that a person's learning outcomes are obtained through direct (concrete)

experience, the reality that exists in one's life environment, then through artificial objects to the verbal symbol (abstract) (Chien et al., 2020; Suprianti, 2020; Tse et al., 2019; Yuniarni et al., 2020). The more concrete students learn teaching materials through direct experience, the more experience students gain. Conversely, the more abstract students gain experience, for example, only relying on verbal language, the fewer experience students will get (Agustien et al., 2018; Rehusisma et al., 2017; Wulandari, 2020).

Learning encyclopedias from video (audiovisual media) provides better learning outcomes than learning only from encyclopedia textbooks. Video as a learning resource has advantages in learning because it can display moving images and sound, a special attraction because students can absorb messages or information using more than one sense (Dede Trie Kurniawan & Maryanti, 2018; Rachmavita, 2020). It is undeniable that the activities of the Basic Chemistry Practicum in the laboratory are closely related to laboratory equipment and chemicals. The success of achieving the practicum objectives is largely determined by knowing the practitioner's names, uses, and skills using laboratory equipment (Arista & Kuswanto, 2018; Diawati et al., 2017). In addition, the knowledge and skills of practitioners using laboratory equipment also greatly affect work safety in chemical laboratories. Practitioners who are skilled at using laboratory equipment will prevent equipment damage and avoid accidents that can endanger the practitioner's self, others, and even the laboratory as a whole (Abdjul et al., 2019; Grandi et al., 2011; Vysakh et al., 2020).

Encyclopedia of laboratory equipment as enriching teaching materials will help students understand the names, uses, and how to use chemical laboratory equipment. Encyclopedia has benefits for students any benefits for students, including adding insight and knowledge, answers to questions that require facts, being reading material, helping students find assignments, knowing things in detail, knowing the origin of things, being a source of learning, as reference material, as entertainment, and make children love culture more. Given the importance of having knowledge and skills in using chemical laboratory equipment, students should study the Encyclopedia before doing practical work in the laboratory. The Encyclopedia of laboratory equipment is not only important for students or students. Still, it is important for anyone who works in the laboratory, including teachers or lecturers, and researchers.

Conclusion

Based on the results of this development research, it can be concluded that the Encyclopedia of Chemistry Laboratory Equipment to Support Basic Chemistry Practicum Learning is feasible to use in terms of content, presentation, language, media, video, and readability aspects. Following the development procedure, this research is continued with developmental testing, namely practicality, and effectiveness testing. The two last-mentioned tests could not be carried out because practicum activities in the laboratory did not occur due to the WFH (Work From Home) policy due to the COVID-19 pandemic. It also provides information that this research has weaknesses or shortcomings. The feasibility

of developing products is limited to expert validation and readability tests, practicality and effectiveness tests have not been carried out.

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References

Abdjul, T., Ntobuo, N. E., & Payu, C. (2019). Development of Virtual Laboratory-Based of Learning to Improve Physics Learning Outcomes of High School Students. *Jurnal Pendidikan Fisika Indonesia*, *15*(2). https://doi.org/10.15294/jpfi.v15i2.12367.

Agustien, R., Umamah, N., & Sumarno, S. (2018). Pengembangan Media Pembelajaran Video Animasi Dua Dimensi Situs Pekauman di Bondowoso Dengan Model Addie Mata Pelajaran Sejarah Kelas X IPS. *Jurnal Edukasi*, *5*(1), 19. https://doi.org/10.19184/jukasi.v5i1.8010.

Arista, F. S., & Kuswanto, H. (2018). Virtual physics laboratory application based on the android smartphone to improve learning independence and conceptual understanding. *International Journal of Instruction*, *11*(1), 1–16. https://doi.org/10.12973/iji.2018.1111a.

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*, 1–20. https://doi.org/10.25304/rlt.v25.1968.

Chien, S.-Y., Hwang, G.-J., & Jong, M. S.-Y. (2020). Effects of peer assessment within the context of spherical video-based virtual reality on EFL students' English-Speaking performance and learning perceptions. *Computers & Education*, *146*. https://doi.org/10.1016/j.compedu.2019.103751.

Cahyaningrum. D., Tegar, H., Sari, M., & Iswandari, D. (2019). Faktor-faktor yang Berhubungan dengan Kejadian Kecelakaan Kerja di Laboratorium Pendidikan. *Jurnal Pengelolaan Laboratorium Pendidikan, 1*(2), 41 - 47 DOI: https://doi.org/10.33369/mapen.v14i2.12834

Council, N. S. (2011). *Injury Facts Formerly Accident Facts*. NSC Press.

Dede Trie Kurniawan, & Maryanti, S. (2018). Analysis of Math Teacher Candidates' Misconception on the Dynamic Electricity Concept. *Scientiae Educatia: Jurnal Pendidikan Sains*, *7*(1). https://doi.org/10.24235/sc.educatia.v7i1.2481.

Diawati, C., Liliasari, L., Setiabudi, A., & Buchari, B. (2017). Development and validation of creative thinking skills test in the project of laboratory apparatus modification. In *Ideas for 21st Century Education* (1st Editio, Issue August, pp. 185–188). Taylor & Francis Group. https://doi.org/10.1201/9781315166575-46.

Goldstein, M. I., & DellaSala, D. A. (2022). Imperiled: The Encyclopedia of Conservation. *Imperiled: The Encyclopedia of Conservation*. https://doi.org/10.1016/B978-0-12-821139-7.05001-7.

Grandi, R., Falconi, R., & Melchiorri, C. (2011). UniBot Remote Laboratory: A Scalable Web-Based Set-up for Education and Experimental Activities in Robotics. *IFAC Proceedings*, *44*(1). https://doi.org/10.3182/20110828-6-IT-1002.03103.

HCorke. (2016). Using the Encyclopedia of Food Grains to Enhance Student Learning. *Reference Module in Food Science*, *1*. https://doi.org/10.1016/B978-0-08-100596-5.00061-5.

Herga, N. R. (2016). Virtual Laboratory in the Role of Dynamic Visualisation for Better Understanding of Chemistry in Primary School. *Eurasia Journal of Mathematics, Science & Technology Education*, *12*(3). https://doi.org/10.12973/eurasia.2016.1224a.

Huang, D., & Wang, J. (2017). An approach on Chinese microblog entity linking combining baidu encyclopaedia and word2vec. *Procedia Computer Science*, *111*. https://doi.org/10.1016/j.procs.2017.06.007.

Li, Y., Ruan, T., & Hu, F. (2012). Ontology Learning from Online Chinese Encyclopedias. *AASRI Procedia*, *1*. https://doi.org/10.1016/j.aasri.2012.06.044.

Lin, L.-F., Li, Y.-M., & Lin, Y.-H. (2014). A recommender mechanism for social knowledge navigation in an online encyclopedia. *Information Processing & Management*, *50*(5). https://doi.org/10.1016/j.ipm.2014.04.006.

Lukman, A., Hayati, D. K., & Hakim, N. (2019). Pengembangan Video Animasi Berbasis Kearifan Lokal pada Pembelajaran IPA Kelas V di Sekolah Dasar. *Elementary: Jurnal Ilmiah Pendidikan Dasar*, *5*(2), 153. https://doi.org/10.32332/elementary.v5i2.1750.

Marlan, M. (2020). Studi Evaluasi Sarana dan Prasarana Laboratorium Kimia SMA Negeri 5 Bengkulu Selatan. *Jurnal Manajer Pendidikan*, 14 (2), 68 - 74. DOI: https://doi.org/10.14710/jplp.1.2.41-47

Ma, L., Ma, X., Xing, P., & Yu, F. (2022). A hybrid approach based on the HFACS-FBN for identifying and analysing human factors for fire and explosion accidents in the laboratory. *Journal of Loss Prevention in the Process Industries*, *75*. https://doi.org/10.1016/j.jlp.2021.104675.

Muchlis, Ibnu, S., Subandi, & Marfuah, S. (2020). Students' result of learning at chemistry department through assessment of, for, and as learning implementation. *International Journal of Instruction*, *13*(2). https://doi.org/10.29333/iji.2020.13212a.

Nasrallah, I. M., Kak, A. K. El, Ismaiil, L. A., Nasr, R. R., & Bawab, W. T. (2022). Prevalence of Accident Occurrence Among Scientific Laboratory Workers of the Public University in Lebanon and the Impact of Safety Measures. *Safety and Health at Work*, *13*(2). https://doi.org/10.1016/j.shaw.2022.02.001.

Orimogunje, T. (2014). If-regulated Learning Strategies on Academic Performance of Students in Senior Secondary School Chemistry, Ondo State, Nigeria. *US-China Education Review*, *4*(11). https://doi.org/10.23887/ijerr.v5i1.45192.

Pamungkas, A. S., Ihsanudin, I., Novaliyosi, N., & Yandari, I. A. V. (2018). Video Pembelajaran Berbasis Sparkol Videoscribe: Inovasi Pada Perkuliahan Sejarah Matematika. *Prima: Jurnal Pendidikan Matematika*, *2*(2), 127. https://doi.org/10.31000/prima.v2i2.705.

Putri, A., Kuswandi, D., & Susilaningsih, S. (2020). Pengembangan Video Edukasi Kartun Animasi Materi Siklus Air untuk Memfasilitasi Siswa Sekolah Dasar. *JKTP: Jurnal Kajian Teknologi Pendidikan*, *3*(4), 377–387. https://doi.org/10.17977/um038v3i42020p377.

Rachmavita, F. P. (2020). Interactive media-based video animation and student learning motivation in mathematics. *Journal of Physics: Conference Series*, *1663*(1). https://doi.org/10.1088/1742-6596/1663/1/012040.

Rasmawan. (2018). Development of Chemistry Module for Junior High School Based on Inquiry Accompanied by Performance-Based Assessment. *Jurnal Pendidikan Indonesia*, *7*(2), 111–119. https://doi.org/10.23887/jpi-undiksha.v7i2.10617.

Rehusisma, L. A., Indriwati, S. E., & Suarsini, E. (2017). Pengembangan Media Pembelajaran Booklet Dan Video Sebagai Penguatan Karakter Hidup Bersih Dan Sehat. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *2*(9), 1238–1243. https://doi.org/10.17977/jptpp.v2i9.9964.

Rusmawan, A. D. S. K. dan. (2013). the Constraints of Elementary School Teachers. *Cakrawala Pendidikan*, *1*(1), 457–467. https://doi.org/10.21831/cp.v3i3.7409.

Su, C. ., & Cheng, T. . (2019). A Sustainability Innovation Experiential Learning Model for Virtual Reality Chemistry Laboratory: An Empirical Study With PLS-SEM and IPMA. *Sustainability*, *11*(4), 1027. https://doi.org/10.3390/su11041027.

Suprianti, G. A. P. (2020). Powtoon animation video: a learning media for the sixth graders. *VELES Voices of English Language Education Society*, *4*(2), 152–162. https://doi.org/10.29408/veles.v4i2.2536.

Tatli, Z. (2010). Virtual laboratory applications in chemistry education. *Procedia - Social and Behavioral Sciences*, *9*, 938–942. https://doi.org/10.1016/j.sbspro.2010.12.263.

Tockner, K., & Mehner, T. (2022). Introduction to Encyclopedia of Inland Waters, 2nd Edition. *Encyclopedia of Inland Waters (Second Edition)*. https://doi.org/10.1016/B978-0-12-819166-8.09962-X.

Tse, W. S., Choi, L. Y. A., & Tang, W. S. (2019). Effects of video-based flipped class instruction on subject reading motivation. *British Journal of Educational Technology*, *50*(1), 385–398. https://doi.org/10.1111/bjet.12569.

Vysakh, K. K., Sharanya, M., & Krishnashree, A. (2020). Virtual Experimental Platforms in Chemistry Laboratory Education and its Impact on Experimental Self-Efficacy. *Journal of Educational Technology in Higher Education*, *17*(30), 1–22. https://doi.org/10.1186/s41239-020-00204-3.

Walker, J. P., Van Duzor, A. G., & Lower, M. A. (2019). Facilitating Argumentation in the Laboratory: The Challenges of Claim Change and Justification by Theory. *Journal of Chemical Education*, *96*(3), 435–444. https://doi.org/10.1021/acs.jchemed.8b00745.

Wan Yunus, F., & Mat Ali, Z. (2018). Attitude towards Learning Chemistry among Secondary School Students in Malaysia. *Asian Journal of Behavioural Studies*, *3*(9), 63. https://doi.org/10.21834/ajbes.v3i9.61.

Wright, J. S., Read, D., Hughes, O., & Hyde, J. (2018). Tracking and assessing practical chemistry skills development: practical skills portfolios. *New Directions in the Teaching of Physical Sciences*, *13*(1). https://doi.org/10.29311/ndtps.v0i13.2905.

Wulandari, Y. (2020). Pengembangan Media Video Berbasis Powtoon pada Mata Pelajaran IPA di Kelas V. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, *8*(2). https://doi.org/10.24815/jpsi.v8i2.16835.

Yuniarni, D., Sari, R. P., & Atiq, A. (2020). Pengembangan Multimedia Interaktif Video Senam Animasi Berbasis Budaya Khas Kalimantan Barat. *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*, *4*(1), 290. https://doi.org/10.31004/obsesi.v4i1.331.

Zammiluni, Ulianas, A., & Mawardi. (2018). Development of guided inquiry based work sheet with class and laboratory activity on chemical bonding topic in senior high school. *International Journal of Chemistry Education Research*, *2*(1). https://doi.org/10.20885/ijcer.vol2.iss2.art1.