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Effectivity Improving Chemistry Laboratory Literacy Levels Through The Development of e-EncyLab Using 3D Pageflip Professional

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Abstract

This research aims to determine the effectiveness of chemistry laboratory literacy levels by developing an e-EncyLab using 3D Pageflip Professional. This study employs a quantitative research methodology. The participants were 10th-grade students. Data was collected using a set of 12 essay questions designed to assess chemistry laboratory literacy, available in the e-EncyLab. Increasing laboratory literacy level abilities can be determined using the N-gain test. The results of this research showed an increase in N-Gain of 0.68 in the medium category. The effect of using e-EncyLab in increasing chemistry laboratory literacy is shown by the results of the paired sample test, which shows sig 0.000 < sig 0.05, which means there is a significant difference in the level of chemistry laboratory literacy of students in the control class and the experimental class that uses e-EncyLab. The use of e-EncyLab is effective in increasing students' chemistry laboratory literacy.

Keywords: e-Encylab, chemistry laboratory literacy, Laboratory Security and Safety

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1. Introduction

Science education aims to equip students with essential skills to navigate rapid advancements in science and technology and address real-life challenges, necessitating a transformation in teaching methodologies (Niess, 2005). Enhancing scientific literacy, particularly in chemistry, is crucial for fostering a deeper understanding of the subject and its applications. In the 21st century, students must develop both scientific and digital literacy to effectively engage with scientific concepts and practices (Annisa & Laksono, 2021; Wangid et al., 2021). Improving scientific literacy in chemistry enhances problem-solving skills, critical thinking, and informed decision-making. Moreover, digital literacy supports the integration of technology into learning processes, improving educational outcomes. By leveraging these competencies, educators can create dynamic and immersive learning experiences that cater to diverse learning styles.

Chemistry education must integrate theoretical knowledge and practical laboratory activities to support classroom learning and enable students to validate theories through hands-on experimentation (Zuhaida & Imaduddin, 2019). Laboratories are essential for demonstrating and verifying scientific concepts, enhancing students' critical thinking skills (Budiarti et al., 2016; Agastya, 2017). Focusing on laboratory literacy is crucial in chemistry education. Effective strategies include guided inquiry-based learning with ethnoscience (Imansari et al., 2018) and developing chemical literacy, especially in areas like waste management (Laksono, 2018). Observations by Thummathong and Kongsak (2018) of varying chemical literacy levels among engineering students in Thailand highlight the need for improved strategies. Additionally, contextual learning designs bridge the gap between theoretical knowledge and practical application, making learning more relevant and engaging for students (Trianto, 2008).

In vocational high schools (SMK), chemistry is often categorized as either an adaptive or supportive subject, which should contribute to the enhancement of productive subjects (Solikha, 2018). Given that productive subjects involve substantial practical content, students must possess the skills and understanding necessary for laboratory work, including safety and security. Yamin (2020) underscores the importance of health and safety behavior during practical sessions, highlighting that effective laboratory practices are essential for this requirement. Consequently, enhancing laboratory literacy through targeted educational tools and strategies is crucial for improving both theoretical and practical aspects of chemistry education in vocational settings.

Based on an interview with a chemistry teacher, it was revealed that incomplete laboratory facilities and insufficient student literacy skills present significant challenges. Students often find chemistry to be a novel subject due to a lack of prior exposure in junior high school, complicating the design of effective laboratory activities (Wahyuni & Yusmaita, 2020). This situation underscores the need for improved resources and strategies to enhance chemistry literacy and support more effective teaching and learning in laboratory settings.

Raharjo (2017) emphasized that selecting appropriate instructional materials can significantly impact students' scientific literacy and abilities. The issue lies in the instructional materials commonly utilized by teachers, which often lack examples or questions that connect the topic being taught to real-life applications. Consequently, most students read without understanding how to apply the concepts they have learned to their immediate environment. Supporting this view, Solikha (2015) demonstrated that tailored teaching materials could enhance students' comprehension of both productive and adaptive chemistry concepts. Ginanjar and Akmal (2021) also showed that student worksheets could effectively improve mathematical literacy among PGSD students, while Harahap (2020) found that science-based worksheets significantly enhanced scientific literacy regarding the human digestive system. Furthermore, Noviati et al. (2022) highlighted the effectiveness of Higher Order Thinking Skills (HOTS)-based worksheets in enhancing critical thinking abilities among high school students. These studies suggest that well-designed instructional materials, including worksheets, can significantly improve literacy levels across various subjects, including chemistry.

Encyclopedias can be used as teaching materials that contain information about safety and security in chemical laboratories, working in synergy with productive subjects that require accuracy and skill in the laboratory. Winda et al. (2018) also utilized encyclopedias as a learning resource, providing knowledge on the functions and usage of laboratory equipment. This development was driven by the lack of reference books facilitating the use of chemical laboratory equipment. According to Hidayat et al. (2015), combining images and colors in an encyclopedia can mitigate the effects of boredom often associated with print media. Image media offers several advantages: it can make concepts more tangible, prevent and correct misconceptions, help students visualize objects, skills, processes, and ideas, and is widely available.

Given the importance of engaging and effective teaching materials in the chemistry learning process, particularly for ensuring safety and security in chemical laboratories at vocational high schools, this research aims to produce innovative, effective, and applicable teaching resources tailored to students' needs. The development of interactive learning tools can enhance student engagement and reduce boredom, as emphasized by Pedra et al. (2015). Jaya (2010) also highlights the effectiveness of virtual laboratories in improving student competencies in vocational subjects, underscoring the potential benefits of integrating interactive and visually rich educational resources in chemistry education. This research is crucial in developing teaching materials that meet the practical and educational needs of students.

Observations at SMK YAPIM Siak Hulu indicate that students are provided with WiFi throughout the school environment and an adequate computer laboratory, facilitating the implementation of e-EncyLab. Interviews with several vocational high school chemistry teachers in Kampar Regency revealed frequent challenges in teaching students who are unfamiliar with chemistry. Additionally, a chemistry teacher at SMKN 1 XIII Koto Kampar noted the absence of reference books on chemical laboratory equipment, despite the essential competency requirements for students to understand laboratory safety and security. Addressing this issue requires providing knowledge about the use of chemical laboratory equipment.

Therefore, this research aims to develop an electronic encyclopedia about chemistry laboratories, named the Electronic Encyclopedia Chemistry Laboratory (e-EncyLab), focusing on chemical laboratory security and safety for vocational high school students. It is hoped that this encyclopedia will provide appropriate knowledge tailored to the needs of these students and help teachers synergize chemistry lessons with productive subjects.

The e-EncyLab teaching material is developed as an e-module using the 3D PageFlip Professional application, which supports motion animations, videos, and audio, creating an interactive and engaging learning experience accessible both offline and online. The application's capabilities make the learning process interactive, capturing students' interest and preventing monotony. Previous studies have demonstrated the effectiveness of 3D PageFlip Professional in educational settings. Marganda et al. (2021) highlighted improvements in student engagement and understanding of absolute value concepts, while Syahrowardi and Permana (2016) noted positive student feedback on the interactivity and ease of use of multimedia handouts designed using this application. These findings underscore the potential of e-EncyLab to enhance students' chemistry laboratory literacy by leveraging the interactive features of 3D PageFlip Professional, aligning with the growing trend of integrating multimedia tools in education to foster a more dynamic and effective learning environment.

2. Research Method

The methodology used in this research is a quantitative method. The design of this research is to test the hypothesis using a pretest-posttest control group design (Sugiyono, 2013; Triyono, 2013). The sample in this study was class X students of YAPIM Siak Hulu Vocational School, Kampar, Riau. Data collection techniques from the results of n-gain analysis from the results of pre-test and posttest questions.

3. Result and Discussion

The data collection tool used was chemistry laboratory literacy level questions, consisting of 12 essay questions. These questions are designed based on aspects of laboratory literacy assessment, which refer to four aspects of scientific literacy: context, knowledge, skills, and attitudes (OECD, 2016).

Increasing laboratory literacy level abilities can be seen using the N-gain test. Before looking at the increase in laboratory literacy level using N-gain, first look at the average difference before and after using e-EncyLab with the paired sample t test. One of the requirements for the paired sample t test is that the data must be normally distributed.

3.1. Normality Test

The data normality test is used to determine the distribution of data, whether it is normally distributed or not. The normality test in this research was carried out on each pretest and posttest data. Data processing using the Shapiro-Wilk formula with the help of the Statistical Package for Social Sciences (SPSS) 16.0 software program. The guidelines or measurements used to state whether data comes from a normally distributed population or not are stated as follows: if the significance value or probability value is smaller than alpha or an error rate of 5% then the data being analyzed is distributed abnormally. If the significance value or probability value is greater than alpha or an error rate of 5% then the data being analyzed is normally distributed.

Based on the results of the normality test using the Shapiro-Wilk statistical technique with the help of SPSS 16.0, the significance level values were obtained which can be seen in Appendix 1 and presented in Table 1.

Table1. Normality Test Results for Laboratory Literacy Level Data

No	Experi-ment class	Value Statistic Shapiro -Wilk	Sig	Add
1	Pretest	0.935	0.154	Normal
2	Posttest	0.933	0.141	

Based on the normality test above, it is known that both data are normally distributed. This shows that the students' pretest and posttest scores are normally distributed, so the data is suitable for testing further analysis using the t test.

3.2. Hypothesis Test Results

The statistical test used to test the hypothesis uses a paired sample t-test with the help of the Statistical Package for Social Sciences (SPSS) 16.0 software application with conclusions drawn at a significance level of 5%. If the significance value is > 0.05 then Ho is accepted and Ha is rejected. Conversely, if the significance value is <0.05, Ho is rejected and Ha is accepted. The hypotheses tested in this research are as follows:

Ho: There is no significant difference in the laboratory literacy level of students in the class before using e-EncyLab and after using e-EncyLab.

Ha: There is a significant difference in the level of laboratory literacy of students in class before using e-EncyLab and after using e-EncyLab.

Based on the data calculations that have been carried out, the analysis results are presented in Table 2.

Table 2. Results of Hypothesis Test Data Analysis (Pretest-Posttest) Chemistry Laboratory Literacy Level

Data	Mean	SD	T count	Sig.	Coclution
Pre-test	51.24	6.37	24.24	0,00	Significant
Post-test	83.98	4.11			

Based on the table above, it is found that the sig value = 0.000. This means that the sig value is 0.05 smaller at the 5% significance level, thus Ho is rejected, which means there is a significant difference in the chemistry laboratory literacy level of students in the class before using e-EncyLab and after using e-EncyLab.

Meanwhile, the independent sample t-test was carried out with the help of the Statistical Package for Social Sciences (SPSS) 16.0 software application with conclusions drawn at a significance level of 5%. If the significance value is > 0.05 then Ho is accepted and Ha is rejected. Conversely, if the significance value is <0.05, Ho is rejected and Ha is accepted. The hypotheses tested in this research are as follows:

Ho: There is no significant difference in the laboratory literacy level of students in the control class and the experimental class who use e-EncyLab

Ha: There is a significant difference in the laboratory literacy level of students in the control class and the experimental class who use e-EncyLab

Based on the data calculations that have been carried out, the analysis results are presented in Table 3.

Table 3. Hypothesis Test Data Analysis Results (Control Class - Experimental Class) Chemistry Laboratory Literacy Level

Data	Mean	SD	T count	Sig.	Conclusion
C. C	74.75	6.55	5.25	0,00	Signi-
C. E	84.50	4.06	5.13	0,00	ficant

Based on the table above, it is found that the value of each class has a sig = 0.000. This means that the sig value is 0.05 smaller at the 5% significance level, thus Ho is rejected, which means there is a significant difference in the level of chemistry laboratory literacy of students in the control class and the experimental class that uses e-EncyLab.

3.3 Analysis of Increasing Chemistry Laboratory Literacy Levels

Literacy level data analysis was carried out through the N-gain score which aims to determine the magnitude of the increase in students' laboratory literacy levels after using e-EncyLab. The results of the N-gain score test analysis of students' laboratory literacy level test data can be seen in Table 4.

Table 4. Results of Analysis of Increasing Chemistry Laboratory Literacy Levels

Class	Aspect	Pretest Score	Posttest Score	Ideal Score	G	Category
Control	Context	73	94	120	0.44	Medium
	Knowledge	233	344	480	0.44	Medium
	Skills	96	123	160	0.42	Medium
	Attitude	60	92	120	0.53	Medium
		Average			**0.45**	**Medium**
Experiment	Context	70	114	132	0.7	High
	Knowledge	259	432	528	0.64	Medium
	Skills	100	122	176	0.72	High
	Attitude	67	112	132	0.69	Medium
		Average			**0.68**	**High**

Based on Table 4, it is known that the increase in the control class and experimental class was 0.45 and 0.68 respectively in the moderate improvement category. The following describes the magnitude of the improvement in each aspect of the experimental class.

3.3.1. Aspect I (Context)

The context aspect is characterized by indicators that involve explaining local, global, or national issues related to science, particularly within the fields of chemistry and technology laboratories. This aspect showed an improvement, with an increase of 0.7 into the high category. This enhancement is attributed to the e-EncyLab's consistent presentation of contextual aspects through phenomena relevant to students' lives, specifically in chemistry and technology laboratories. In the PISA assessment, context is framed within broader life situations, extending beyond the confines of the school environment (OECD, 2016).

The e-EncyLab effectively incorporates real-world societal issues and problems, aligning with the goal of making science education more relevant and engaging. By integrating these issues, the e-EncyLab provides students with practical examples that directly relate to the concepts they are learning. This approach not only aids in the comprehension of theoretical knowledge but also enhances students' ability to apply scientific concepts to everyday situations. Such contextualization bridges the gap between academic content and real-life applications, ultimately making the learning experience more meaningful and impactful (Gilbert, 2011).

3.3.2. Aspect 2 (Knowledge)

The second aspect that experienced the highest increase was the knowledge aspect with a value of 0.64 in the medium category. This aspect of knowledge contains students' understanding of the main facts, concepts, theories, procedural and rational aspects that underlie scientific knowledge. In the developed e-EncyLab, laboratory knowledge is presented which consists of content knowledge, procedural knowledge and epistemic knowledge. This is in accordance with the knowledge components required in laboratory literacy according to OECD (2016). The knowledge presented in e-EncyLab is accompanied by relevance to real situations and is adapted to the level of development of students' thinking.

3.3.3. Aspect 3 (Skills)

The competency aspect experienced the highest increase of 0.72 in the high category. This aspect includes an understanding of scientific issues and phenomena and the ability to use scientific evidence. This aspect experienced the greatest increase compared to other aspects. This is because to use scientific evidence to explain an issue or phenomenon requires special teaching materials and methods that can be carried out theoretically or experimentally. In e-EncyLab, only theoretical displays are used, while videos or simulations are used to explain abstract concepts. Simulations and games can help students visualize objects and processes that cannot be seen directly (Pedra et al., 2015).

3.3.4. Aspect 4 (Attitude)

The attitude aspect increased by 0.69 in the medium category. The attitude aspect includes interest in the laboratory and awareness of environmental issues. The E-EncyLab used has presented several phenomena and explanations so as to increase interest in the laboratory and awareness of the surrounding environment. To increase laboratory interest, e-EncyLab presents scientific phenomena in life. This is supported by research by Afifah (2020) who also developed a pocket book based on scientific literacy to increase students' interest in learning science. To increase environmental awareness, the e-EncyLab presents the phenomenon of danger signs for chemicals so that people can be more careful in using chemicals. This is expected to foster a caring attitude towards the environment in students. This is supported by research by Junita (2018) which concludes that the community science technology (STM) approach can increase students' awareness of the environment.

4. Conclusion

The conclusion of this research is that there is an increase in N-Gain of 0.68 in the medium category. and The effect of using e-EncyLab in increasing chemistry laboratory literacy is shown by the results of the paired sample test which shows sig 0.000 < sig 0.05, which means there is a significant difference in the level of chemistry laboratory literacy of students in the control class and the experimental class who use e-EncyLab. It can be interpreted that the use of e-EncyLab is effective in increasing the level of laboratory literacy and increasing the level of chemistry laboratory literacy of students.

The significant increase in chemistry laboratory literacy through the use of e-EncyLab demonstrates the effectiveness of digital resources in improving educational outcomes. This suggests that educators should integrate such tools into their curricula to enhance student engagement and learning. Future research should explore the long-term impact of e-EncyLab on students' practical skills and academic performance. Additionally, expanding the use of similar technologies in other scientific fields could further support effective teaching methods. Regular feedback from users is crucial for the continuous refinement and enhancement of e-EncyLab to better meet educational needs.

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