The Effect of Buffer Solution Students' Worksheet Based on Problem-Based Learning With Ethnochemistry Nuances Integrated Technology to Improve Students' Science Literacy Ability

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Abstract. The limited science literacy proficiency of the pupils hinders their capacity to effectively use scientific principles in solving real-world situations. The objective of this study is to examine the impact of incorporating buffer solution students' worksheets, which are based on problem-based learning with ethnochemistry subtleties and integrated technology, on enhancing students' science literacy skills. The study methodology employed is quasi-experimental research, namely in the form of a nonequivalent control group design. The population comprises students enrolled in phase F of SMA Negeri 3 Padang for the academic year 2022/2023. The sample was selected via purposive sampling. The research data analysis was conducted utilizing the N-gain test and hypothesis testing employing the t-test. The data analysis revealed that the N-gain value for the experimental class was 0.86, falling within the high category. This resulted in a significant improvement of 73.31% in students' science literacy ability, classified as good. The hypothesis test yielded a t_{count} value of 8.56, which exceeded the critical t_{table} value of 1.66. Therefore, the research hypothesis was accepted. The results validate that the use of a buffer solution students' worksheet, which incorporates problem-based learning with ethnochemistry subtleties and integrated technology, has a substantial positive impact on the science literacy skills of students at SMAN 3 Padang.

Keywords: students' worksheets, problem-based learning, ethnochemistry, science literacy

1 Introduction

The Program for International Student Assessment (PISA), administered by the Organization for Economic Co-operation and Development (OECD), seeks to evaluate students' competence in science literacy. PISA statistics from 2000 to 2018 regularly classified Indonesian pupils among the 10 lowest-performing countries. However, it's worth noting that the 2022 PISA results showed a significant decline in performance in mathematics, reading, and science, marking the lowest overall scores ever recorded by PISA in these three subjects. The results of this test show that Indonesian education in

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general has not succeeded in producing students who have good reasoning, literacy, and numerical skills [1]. This is very concerning because science literacy ability and skills are the basis for students to gain knowledge in solving problems, thinking critically, logically, and taking initiative. Utilizing ethnochemistry-based student worksheets as teaching resources can serve as a viable option for enhancing students' proficiency in scientific literacy [2, 3].

Students will get knowledge, skills, and good attitudes in the learning process. In order for students to integrate the ideas they have learned with observable events in their surroundings, learning activities should be closely aligned with the environment in which they are situated. Learning activities should optimally utilize the potential of the surrounding environment so that learning is more meaningful and applicable for students [4]. This is following the demands of the Merdeka curriculum. The Merdeka curriculum focuses on students' ability to understand and apply the concepts they have in solving contextual problems.

Currently, the implementation of integrating the learning process at school with the contextual difficulties present in the surrounding environment has been inadequate. Utilizing instructional resources that incorporate cultural values and indigenous knowledge can facilitate students in the practical application of their conceptual understanding. Student worksheets are a type of instructional material that may be utilized during the learning process [5].

Student worksheets are educational resources that consist of tasks that students are required to complete in order to attain certain learning objectives. Student worksheets can enhance teaching and learning by promoting effective interaction between students and teachers [6]. Student worksheets can improve the teacher's function as a facilitator. This is because the employment of student worksheets increases the student-centered learning process. Furthermore, the employment of student worksheets can increase learning results and promote students' competence in scientific literacy [7]. Student worksheets can be integrated with problems that students encounter in everyday life so that learning becomes more applicable. Using student worksheets that are integrated with contextual problems can help students apply the concepts they have in real contexts. In this way, students' problem-solving ability will increase so that the learning process becomes more meaningful [8]. The use of teaching materials can be equipped with learning models so that the learning process becomes more focused [9]. One learning model that is relevant and develops students' problem-solving ability involves the Problem-Based Learning (PBL) model [10].

The problem-based learning style gives an opportunity for pupils to think critically in addressing challenges. Students will reassemble the information they previously had with new knowledge to discover answers to contextual challenges so that learning becomes more meaningful [11]. The problem-based learning methodology is student-centered. Students are needed to be actively involved in seeking ways to address the problem by using the knowledge they learned, acquired alone or in groups [12, 13]. The adoption of problem-based learning in the learning process can be associated to ethnochemistry. Ethnochemistry is a chemistry learning technique that explores chemical material based on a cultural perspective. The learning that integrates ethnochemistry

not only enhances students' understanding capacity but can also conserve local culture so that the learning process becomes more useful.

Student worksheets based on problem-based learning with ethnochemistry nuances integrated technology can be used as teaching material that helps students strengthen and apply the concepts of the material studied to solve contextual problems that exist in their lives. The usage of student workbooks integrated with technology can promote contact between teachers and students so that learning activities would be more productive and efficient. Apart from that, technology integration in student worksheets can help students with limited learning styles because students can access video and audio from the worksheets developed. Integrating technology in student worksheets can support differentiated learning processes [14].

Research conducted by Ariningtyas et al. in 2017 [4] found that ethnochemistry can help students associate and apply the concepts of material studied with the local culture of Semarang. Apart from that, ethnochemistry is also effective in improving students' science literacy ability in salt hydrolysis material. So that the learning process becomes more interesting and meaningful and students' literacy ability increases. Research conducted by Asda et al. in 2023 has produced a buffer students' worksheet with ethnochemistry nuances integrated technology that is valid, practical, and effective. The ethnochemistry raised in this student worksheets is Minangkabau culture which is connected to buffer solution materials. Therefore, researchers intended to perform a study on how PBL-based buffer solution student worksheets with ethnochemistry nuances coupled with technology increase their science literacy abilities.

2 Method

The research approach adopted was quasi-experimental. The population in this study comprised of students in the XI.F phase of SMA Negeri 3 Padang for the 2022/2023 school year and the sample was taken by purposive sampling. The study design was carried out employing a nonequivalent control group design which is indicated in Table 1.

Table 1. Nonequivalent Control Group Design

Class	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2
Control	O_1	-	O_2

Based on the study design which can be observed in Table 1 with X = learning utilizing buffer solution students' worksheet; O_1= initial test; and O_2 = final test [15]. The experimental class uses buffer solution students' worksheets based on PBL with ethnochemistry nuances integrated technology in the learning process, while the control class uses conventional teaching materials provided by the school in the learning process. The instrument tests used in this research are multiple choice questions which were developed by Sumarni et al., in 2016 and have been tested for their feasibility in

measuring the level of students' science literacy ability [16]. Students' science literacy abilities are classified based on percentages which can be shown in Table 2.

Table 2. Science Literacy Ability Category

Scientific Literacy Ability (%)	Category
80 – 100	Very High
66 – 79	High
56 – 65	Medium
40 – 55	Low
0 – 39	Very Low

The data analysis approach in research combines quantitative data analysis with hypothesis testing. To test the hypothesis, a normality and homogeneity analysis must be undertaken collected first. The normality test was carried out using the Liliefors formula whilst the homogeneity test was carried out using the Fisher formula. Parameters for hypothesis testing may be observed from the t_{table} value, which is based on a given level of significance and has degrees of freedom (df) calculated as $df = n_A + n_B - 2$. If $t_{\text{count}} > t_{\text{table}}$, then H_0 is rejected, and if $t_{\text{count}} < t_{\text{table}}$, then H_0 is accepted [17].

3 Result and Discussion

This research intends to assess the effect of adopting buffer solution students' worksheets based on PBL with ethnochemistry nuances integrated technology to increase students' scientific literacy ability. Minangkabau local wisdom that is connected with buffer solution materials is manyiriah activities, making kue bika and preserving sambalado mudo. Research data was obtained based on data collection carried out at SMAN 3 Padang. This research covered two classes, namely the experimental class and the control class each consisting of 32 students. The experimental class studied utilizing buffer solution students' worksheets whereas the control class studied using traditional teaching materials.

Students' science literacy ability can be measured using multiple-choice questions equipped with reasons [18]. To measure students' literacy ability, students' scientific literacy ability must be tested before and after carrying out the learning process. The outcomes of students' initial students' science literacy abilities in both classrooms may be shown in Table 3.

Table 3. Students' Initial Science Literacy Ability

Class	Science Literacy	Category
Experimental	20.94 %	Very Low
Control	21.66 %	Very Low

The science literacy ability of pupils in both classrooms was originally in the extremely poor level. After performing learning in two courses according to the previously decided treatment, there was an increase in the science literacy capacity of students in both classes as indicated in Table 4.

Table 4. Students' Final Science Literacy Ability

Class	Science Literacy	Category
Experimental	86.88 %	Very High
Control	77.94 %	High

Based on Table 3 and Table 4, it can be noticed that there was an increase in science literacy ability in both courses, but the development in science literacy ability of students in the experimental class was bigger than in the control class. The science literacy ability of the experimental class was in the very high category whereas the science literacy ability of the control class youngsters was in the high category. The percentage difference in enhancing the science literacy ability of experimental class students was 70.28 %, whereas the percentage difference in extending the science literacy ability of control class students was 61.72 %. This reveals that the science literacy abilities of experimental class children is greater than those in the control class. To find out whether the buffer solution students' worksheet has a considerable impact on students' science literacy ability, a hypothesis test was done out. Hypothesis testing was carried out to establish if there was a substantial gain in students' scientific literacy abilities in both classes. Before evaluating the hypothesis, a normality test and homogeneity test are first carried out to verify whether the data is normally and homogeneously distributed. The normality test findings were carried out using the Liliefors method and the normality test results may be found in Table 5.

Table 5. Normality Test Result

Class	L_{count}	L_{table}	Description
Experimental	0.073	0.156	Normal
Control	0.138	0.156	Normal

Based on the results of normality analysis Table 5 demonstrates that both sample classes are normally distributed, thus Fisher's test is next carried out to evaluate if the samples are homogeneously distributed. The results of the Fisher test may be seen in Table 6.

Table 6. Homogeneity Test Result

Class	F_{count}	F_{table}	Description
Experimental	1.772	1.791	Homogeneous
Control	1.772	1.791	Homogeneous

The data in Table 6 demonstrates that the two sample groups have homogeneous variances. This is because the two sample classes do not have appreciably different levels of variation in values. To see significant disparities in students' science literacy abilities in the two sample classrooms, a hypothesis test was carried out. The independent t-test may be applied since the data is normally distributed and homogeneous. Hypothesis test results may be found in Table 7.

Table 7. Hypothesis Test Result

Class	t_{count}	t_{table}
Experimental	8.56	1.66
Control	8.56	1.66

Table 7 illustrates the results of the hypothesis test data processing analysis achieved by the value of $t_{count} > t_{table}$. From these results, it can be concluded that the research hypothesis is accepted. In other words, the deployment buffer solution students' worksheet based on PBL with ethnochemistry nuances integrated technology may increase students' science literacy ability. The increase in science literacy ability in the experimental class was because students who studied with buffer solution students' worksheets based on PBL with ethnochemistry nuances integrated technology had the scientific knowledge to discover concepts and apply the concepts they had in solving contextual problems according to the steps in the student worksheets.

Increasing students' science literacy ability is also influenced by teaching materials with ethnochemistry nuances. Local wisdom applied in learning makes learning more applicable because it prioritizes the usefulness of students' concepts and is strengthened by scientific discoveries related to local culture. Learning chemistry by involving local wisdom will help students learn chemistry according to the local culture in their area [4]. Teachers are expected to be able to integrate local culture into learning and develop teaching materials that can build students' science literacy ability linked to local wisdom.

The application of PBL in students' worksheets can facilitate students to improve their abilities in solving scientific problems in processes in their environment. Students must be accustomed to searching for information on their own, able to identify and formulate problems, able to work effectively in groups and be actively involved in problem-solving. PBL activities can encourage students to increase their curiosity, thereby motivating students to increase their interest in scientific problems. This will help increase students' sense of responsibility towards the surrounding environment by applying the chemical concepts they have learned [19]. Increasing students' science

literacy capacity is also impacted by access to learning through technology supplied in instructional resources. Integrating technology into educational materials can help the differentiated learning process. The use of information technology in the chemical learning process can stimulate and encourage pupils to learn independently [20]. The designed buffer solution students' homework based on PBL with ethnochemistry nuances integrated technology buffer solution students' worksheet based on PBL with ethnochemistry subtleties integrated technology aids differentiated learning since it may help students with diverse learning styles such as visual, auditory and kinesthetic. Barcodes on student workbooks may be accessed by students to see movies, listen to audio and even complete out worksheets and assessment questions.

Another study also revealed that the use of student worksheets based on PBL with ethnochemical nuances was effective on students' science literacy ability [4]. Students who learn using student worksheets based on PBL with ethnochemical nuances find it easier to follow the learning because they have been guided by steps according to the PBL model. Differences in the results of students' science literacy ability were seen during the learning process in the experimental class and control class. In the control class, most students were not able to identify and apply scientific knowledge to the concept of buffer solutions. Meanwhile, in the experimental class, most of the students were able to identify keywords to find scientific information and were able to connect buffer solution material in solving problems contextually and logically in answering questions. Based on the data analysis that has been carried out, it can be determined that the buffer solution students' worksheet based on PBL with ethnochemistry nuances integrated technology may greatly increase the science literacy ability of students at SMA 3 Padang.

4 Conclusion

Based on the results of data processing, it can be concluded that the implementing buffer solution students' worksheet based on PBL with ethnochemistry nuances integrated technology can significantly improve the science literacy ability of students at SMA 3 Padang. Thus, this buffer solution students' worksheet can be used as alternative teaching material that contains elements of local Minangkabau cultural wisdom which can improve students' science literacy ability so that the learning process becomes more meaningful and applicable for students.

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