Development of Buffer Solution Students' Worksheet Based on Problem Based Learning with Ethnochemistry to Improve Students' Science Literacy Ability

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Abstract: Merdeka curriculum emphasizes the ability of students to understand and apply their concepts to solve contextual problems. This research aimed to determine the validity, practicality, and effectivity of buffer solution students' worksheet based on problem based learning with etnochemistry on students' science literacy ability. The development model used in this research is 4-D. buffer solution students' worksheet was validated by 3 chemistry lectures and 2 chemistry teachers. Practicality tests were carried out by 3 chemistry teachers and 32 students. Then, the level of effectiveness of buffer solution students' worksheet is known through the N-gain test. The validity test was analyzed by using aiken's v derived formula consisting the validity of the content and construct which was 0.91 and 0.90 with category valid. The results of the practicality of teachers and students was 88.80 and 87.75 with higher category. Analysis of the n-gain value obtained the results of the value of $g = 0.86$ in the high category. Then the date analyzed with quantitative method by using hypotheses testing, determined that the research hypothesis was accepted. This result confirmed that buffer solution students' worksheet based on problem based learning with ethnochemistry was valid, practical, and effective to improving students' science literacy ability significantly.

Keywords: Buffer solution; Ethnochemistry; Problem based learning; Science literacy; Students worksheet

Introduction

Merdeka curriculum focuses on students' ability to understand and apply their concepts in solving contextual problems. The existence of teaching materials that contain cultural values and local wisdom can help students apply their concepts in real contexts. One of the teaching materials that can be used in the learning process is student worksheets (Suryaningsih & Nurlita, 2021). Buffer solution is one of the chemical materials studied by students in Phase XI.F SMA/MA. Buffer solution material has an abstract scope of factual, procedural and conceptual knowledge. To understand this material, a representative teaching material is needed to support students to observe and analyze phenomena related to the buffer solution material and its relation to everyday life. One of the teaching materials that can be used is student worksheets.

The student worksheet is a teaching material containing sheets of assignments that must be done by students in accordance with the learning objectives to be achieved (Nuraeni, 2022). The use of student worksheets in the learning process can facilitate and assist teaching and learning activities so that effective interactions are formed between students and teachers (Munawarah et al., 2020). The use of teaching materials can be integrated with learning models so that the learning process becomes more directed (Asda & Andromeda, 2021). The problem based learning model provides space for students to think critically in solving problems. Students will reconstruct their previous knowledge with new knowledge to find contextual problem-solving solutions so that learning becomes more meaningful (Sanova et

al., 2021). This learning model is centered on students (student-center). Students are required to be actively involved in finding solutions to problem solving by applying the concepts they have both individually and in groups (Priscylio et al., 2019; Sari & Andromeda, 2023).

The very rapid technology resulted in the free entry of foreign culture and began to displace local wisdom. The lack of innovation in the introduction of culture is one of the causes of the fading of national culture (Gutiawati & Wulansari, 2022). Therefore, schools as a central base of knowledge need to include learning content that contains local wisdom by linking teaching materials with cultural elements. Ethnochemistry is a branch of science that studies chemistry based on a cultural perspective. The learning process with ethnochemical nuances can increase the dimensions of students' knowledge not only in theory but also in preserving local wisdom (Pertiwi et al., 2021). Based on the results of the Program for International Student Assessment (PISA) which aims to test students' literacy competencies, it was found that the scientific literacy skills of Indonesian students while attending PISA for the past 15 years have always been in the top 10 bottom. This is very concerning because reading abilities and skills are the basis for acquiring knowledge in solving problems, thinking critically, logically and taking initiative. Therefore, effective teaching materials are needed to improve students' scientific literacy skills (Wen et al., 2020).

Student worksheets based on problem based learning with ethnochemistry integrated technology can be used as one of the teaching materials that help students in strengthening and applying the concepts of material learned to solve contextual problems. The use of technology-integrated student worksheets can facilitate interaction between teachers and students so that learning activities will be more effective and efficient. In addition, the integration of technology can help the limitations of learning styles that are owned because students can access video and audio from student worksheets that are developed (Abdullah, 2018). Problem based learning will provide experience to students in solving contextual problems independently. Research conducted by Ariningtyas et al. (2017) found that ethnochemistry can help students associate and apply the concepts of the material being studied with the local culture of Semarang. In addition, ethnoscience is also effective in increasing students' scientific literacy skills in salt hydrolysis material. So that the learning process becomes more interesting, meaningful and students' literacy skills increase. The ethnochemistry explored in this study is the Minangkabau local wisdom in material of the buffer solution. Several previous studies have conducted studies related to the development of teaching materials. However, the activities provided have not been linked to the problem based learning model with ethnochemical nuances, especially Minangkabau culture. Based on this, this study aims to develop buffer solution students' worksheets based on problem based learning with ethnochemistry to improve student's science literacy ability.

Method

This type of research is research and development (R&D) with 4-D development model (Sugiyono, 2013). The 4-D development model consists of 4 stages namely define, design, develop, and disseminate. The first stage is definition consists of 5 parts, namely: (a) front end analysis; (b) student analysis; (c) task analysis; (d) concept analysis; (e) analysis of learning objectives. The second stage is design, which is the stage of designing buffer solution students worksheet based on problem based learning with ethnochemistry.

The third stage is development, there are three things that are assessed on the developed student worksheets, namely the assessment of validity, practicality and effectiveness. The validity test consisted of two parts, namely construct validity and content validity. The validity test was carried out by 3 chemistry lecturers and 2 chemistry teachers whose aim was to determine the validity level of the buffer solution student's worksheet. The practicality test was carried out by 3 chemistry teachers and 32 students. The effectiveness test was carried out involving 35 students in phase F of SMAN 3 Padang for the 2022/2023 school year. The results of this test can be used as a consideration whether student worksheets are developed can be used in a wider scope.

The final stage is dissemination. However, this research was only limited to develop stage, namely by testing the level of validity, practicality and effectivity of the developed student worksheets, while the dissemination stage was not carried out due to time constraints.

The instruments used in this study were valid validity questionnaires and practicality questionnaires. Meanwhile, the effectiveness test was carried out using an instrument for assessing students science literacy ability on the supporting material developed by Sumarni et al. (2016) in buffer solution materials, which had been tested for its effectiveness in measuring students' science literacy ability.

The data obtained from the product validity test result were analyzed using the Aiken's V formula as shown in the Equation 1.

$$V = \frac{\sum s}{n(c-1)} \qquad (1)$$

Information: s = r – Io, r = the value given by the validator, Io = lowest validity value, n = number of expert validators, c = highest validity score (Aiken, 1985). The data generated from the practicality test were analyzed using formula as shown in the Equation 2.

$$P = \frac{f}{N} \times 100 \qquad (2)$$

Information: P = final value, f = score, and N = maximum score.

Effectiveness test is done by using one sample class namely phase XI.F 2 were selected by purposive sampling technique. The sample class was given a pretest before starting learning and a posttest at the end of learning. The pretest and posttest results were analyzed using the N-gain formula as shown in the Equation 3.

$$\text{N-gain} = \frac{\text{Posttest Score} - \text{Pretest Score}}{100 - \text{Pretest Score}} \qquad (3)$$

Meanwhile, to see the difference in the level of student's science literacy ability can be seen in the following Table 1.

Table 1. Scientific Literacy Ability Category

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

Technical analysis of data in research is quantitative data analysis by testing hypotheses. To test the hypothesis, normality and homogeneity analysis must be carried out first. The normality test is carried out using the Liliefors formula while the homogeneity test is carried out using the Fisher's formula. Parameters for hypothesis testing can be seen from the ttable price which is based on a certain significance level and has degrees of freedom (dk) = nA + nB – 2, if $t_{count} > t_{table}$, then H_0 is rejected and vice versa if $t_{count} < t_{table}$, then H_0 is accepted (Arikunto, 2012).

Result and Discussion

Define Stage (Definition)

At the frontend analysis stage it is known that: (1) the teaching materials used in the buffer solution material do not contain material that is integrated with contextual issues and related to local wisdom; (2) the teaching materials used have not facilitated students in applying the concepts they have for solving problems in everyday life; (3) the influx of outside cultural influences due to technological developments causes the fading of cultural values; and (4) the low ability of students' science literacy. At the student analysis stage, it is known that students have difficulty understanding the buffer solution material because the concept of buffer solution is abstract and difficult to relate to contextual problems.

In the task analysis stage, an analysis of learning outcomes is carried out, namely using the concept of acid in everyday life. From the analysis of learning outcomes, learning objectives are formulated, namely explaining the concept of buffer solutions, analyzing types of buffer solutions, analyzing the working principle of buffer solutions, calculating the pH of buffer solutions, making buffer solutions and explaining the role of buffer solutions. In the concept analysis stage, the main concepts that will be taught are identified. The analysis stage of learning objectives is formulated based on task analysis and concept analysis.

Based on front end analysis, student analysis, task analysis, concept analysis and learning objectives analysis, a teaching material was developed in the form of buffer solution students worksheet based on problem based learning with ethnochemistry to improve students' science literacy ability.

Design Stage (Design)

Based on the data and problems that have been found at the definition stage, buffer solution student's worksheet with ethnochemistry are produced. An example of a buffer solution student's worksheet that was developed is as follows:

Orientation of Students to the Problems

Figure 1. Orientation of students to the problems stage

At this stage students read discourse, listen to audio, and observe videos that have been presented on student worksheets which contain contextual issues about buffer solution material related to local culture. An example of the display of this stage on the buffer solution students worksheet can be seen in Figure 1.

Organizing Students to Learn

At this stage, students collect information related to the material in the buffer solution that has been determined. Thus, students get facts related to the problems presented in the previous stage. An example of the display of this stage on the buffer solution students worksheet can be seen in Figure 2.

Figure 2. Organizing students to learn stage

Guiding Individual/Group Investigations

At this stage students collect data by conducting investigations or experiments to find solutions to solving problems that have been presented in the previous stage. An example of the display of this stage on the buffer solution students worksheet can be seen in Figure 3.

Figure 3. Guiding individual/group investigations stage

Develop and Present the Work

At this stage students design or present work that is in accordance with the results of problem solving in the form of powerpoint, video or other models. An example of the display of this stage on the buffer solution students worksheet can be seen in Figure 4.

Figure 4. Develop and present the works stage

Analyze and Evaluate the Problem-Solving Process

At this stage students reflect or evaluate the investigation and the processes used in problem solving. An example of the display of this stage on the buffer solution students worksheet can be seen in Figure 5.

Figure 5. Analyze and evaluate the problem-solving process stage

Develop Stage (Development)
Validity Test

Test the construct validity of student worksheets consisting of the validity of content components, presentation components, linguistic components and graphical components. Test the validity of the content of student worksheets consisting of aspects of suitability of the contents of student worksheets with problem based learning syntax and the correctness the contents of student worksheets on chemical scientific content.

Based on the results of data analysis, the average construct validation obtained an average value of 0.90 and content validation obtained an average of 0.91 with valid category. Based on the results of validity analysis shows that the buffer solution students worksheet based on problem based learning with ethnochemistry are developed valid and worthy to be tested in the learning. The Result content validation test of the buffer solution student worksheets is seen in Table 2 and the results of the construct validity test can be seen in Table 3.

Table 2. Content Validity Analysis Results

Rated Aspect	Value V	Category
Suitability of the contents with problem based learning syntax	0.92	Valid
Correctness the contents of students worksheet with chemical scientific content	0.90	Valid
Average	0.91	Valid

Table 3. Construct Validity Analysis Results

Rated Aspect	Value V	Category
Content Component	0.89	Valid
Construct Component	0.90	Valid
Language Component	0.89	Valid
Graphics Component	0.91	Valid
Average	0.90	Valid

Practical Test

The practicality of buffer solution students worksheets based on problem based learning with ethnochemistry was measured by giving practicality questionnaires to 3 chemistry teachers and 32 students. Practicality analysis based on ease of use, efficiency of learning time, and benefits. The average practicality test results for 3 teachers obtained 88.80 in the very practical category, while the practicality test for 32 students obtained 87.75 in the very practical category.

The results of processing the teachers and students practicality questionnaire assessment data on buffer solution students worksheet for each component can be seen in Table 4.

Table 4. Practicality Analysis of Teachers and Students

Aspects	Teachers	Students	Category
Ease of use	88.89	87.24	Very practical
Time efficiency	87.50	88.28	Very practical
Benefit	90.00	87.72	Very practical
Average	88.80	87.75	Very practical

Based on the analysis of the practicality of buffer solution students' worksheets data, the results analysis aspects of the ease of use by chemistry teachers had a practicality value of 88.89 in the very practical category and 87.24 by students in the very practical category. This shows that the buffer solution students worksheet based on problem based learning with ethnochemistry contain material, video, audio, and images that are easy to understand and easy to use.

The results of the analysis of the efficiency aspect of learning time by chemistry teachers and students have a practicality value of 87.50 and 88.28 in the very practical category. This shows that buffer solution student worksheets can help limited time in the learning process so it is efficient to use. Then in the aspect of the benefits by the chemistry teacher and students it has a

practicality value of 90.00 and 87.72 in the very practical category.

From the data analysis carried out, it was found that the buffer solution students worksheet based on problem based learning with ethnochemistry developed were valid and practical for use as alternative teaching materials for high school students and deserved to be tested for their effectiveness in the learning process.

Effectivity Test

This stage aims to determine the level of effectiveness of buffer solution students worksheet based on problem based learning with ethnochemistry on students' science literacy abilities. The research data were obtained after conducting research and data collection at SMAN 3 Padang. The subjects of this study were students in phase XI.F 2 as an experimental class who were given learning treatment using buffer solution students.

The level of effectiveness of buffer solution students worksheet on students science literacy ability can be measured using multiple choice questions supplemented with reasons (Sumarni et al., 2016). To analyze the initial knowledge possessed by students, it is necessary to do a pretest. The results of this pretest are very useful for teachers to see which material should be taught more deeply in the learning process so that the time achieved in the learning process is more effective (Yerimadesi et al., 2019). After participating in the lesson, the students were given a posttest to measure students' understanding and students science literacy ability. The average results of the assessment can be seen in Table 5.

Table 5. Average Result of Test and N-Gain

Average	Pretest	Postest	N-Gain
Students Score	17.66	87.94	0.86

Based on Table 5, it was found that the students' pretest scores were 17.66, while the students' posttest scores were 87.94. Students' posttest scores were higher than students' pretest scores with a difference of 69.58. This shows an increase in learning outcomes and students' science literacy ability after learning using buffer solution student's worksheet. From analysis of N-Gain, the result of N-Gain score is 0.86 in the high category. The categories of increasing students' science literacy ability before and after learning using buffer solution worksheets can be seen in the following Table 6.

Table 6. Average Result of Sciencific Literacy Ability

Sample	Average	Category
Pretest	17.66	Very Low
Posttest	87.92	Very High

Based on Table 6 it can be concluded that the results of the analysis of students' scientific literacy abilities in pretest were 17.66 with very low category and the results of the analysis of students' science literacy ability in posttest were 87.92 in very high category. This shows that buffer solution student's worksheet is effective in improving student science literacy ability. To prove the value of the sample has a significant difference, a hypothesis test is carried out. To test the hypothesis, it is necessary to know in advance whether the data obtained is normally distributed and homogeneous or not. The results of the data normality test using the Liliefors technique can be seen in Table 7.

Table 7. Normality Test Result

Sample	L_0	L_t	Description
Pretest	0.128	0.149	Normal
Posttest	0.124	0.149	Normal

The results obtained in Table 6 show that the sample is normally distributed, so the Fisher/F-test technique can be used to test the uniformity of the data and continue in the second stage. The results of the sample homogeneity test are shown in Table 8.

Table 8. Homogeneity Test Result

Sample	F_{count}	F_{table}	Description
Pretest Posttest	1.364	1.692	Homogeneous

The data in Table 8 shows that the sample have homogeneous variance. This is because the two sample do not have a high or heterogeneous level of variation in test scores. Then it can be continued with the final stage of testing, namely the t-test which is summarized in Table 9.

Table 9. Hypothesis Test Result

Sample	t_{count}	t_{table}
Pretest Posttest	5.8	1.68

Table 9 shows the results of data processing to test the hypothesis obtained with t_{count} (5.8) > t_{table} (1.68) so hypothesis was accepted. Based on the result can be concluded that, the use of buffer solution students worksheet based on problem based learning with ethnochemistry is effective in improving students' literacy ability significantly.

Mastery of scientific literacy skills is influenced by several factors, including the science learning approach or method used by teachers in building learning concepts. Learning that is able to arouse students' curiosity regarding learning topics and encourage students' enthusiasm to solve problems presented by the teacher is believed to be able to build science process skills which are part of the scientific literacy competency aspect (Wulandari & Sholihin, 2016). One learning model that can build students' science literacy ability is problem based learning (Hafizah & Nurhaliza, 2021; Dinda Nur Azizah et al., 2021).

Increasing students' science literacy ability is also influenced by teaching materials that contain ethnochemistry. Local wisdom is more applicable because it prioritizes usability and is reinforced by scientific discoveries. Learning science by involving local wisdom will help students learn science that is in line with student beliefs without being separated from standard concepts that apply universally (Ariningtyas et al., 2017). Teachers are expected to integrate local culture into science learning and develop instruments to measure science literacy ability in a cultural context. The physical dimension of local wisdom raised in this students worksheet is Minangkabau culture, namely traditional ceremonies (*manyiriah*) and traditional food (*sambalado mudo* and *kue bika*).

Increasing students' scientific literacy skills posttest is also influenced by access to learning through technology provided in teaching materials. Technology integration in teaching materials can support the learning process. the use of information technology in the process of learning chemistry can motivate and encourage students to be able to learn independently (Warlinda et al., 2022). The buffer solution students worksheet based on problem based learning with ethnochemistry developed support differentiation learning because they can help students with different learning styles such as visual, auditory and kinesthetic. Barcodes on students worksheet can be accessed by students to observe videos, listen to audio and even fill out worksheets and evaluation questions.

Other studies have also revealed that the use of students worksheet based on problem based learning and ethnochemistry is effective on students' scientific literacy abilities (Ariningtyas et al., 2017). Students who study using buffer solution students worksheet based on problem based learning with ethnochemistry are easier to follow in learning because they have been equipped with the steps according to the problem based learning model. In addition, students can apply their concepts to solve contextual problems related to Minangkabau culture so that the learning process becomes more meaningful.

Conclusion

Based on the results of data processing it was concluded that the developed buffer solution students worksheet based on problem based learning with

ethnochemistry was valid, practical and effective to improving students' science literacy ability significantly.

Author Contributions

Conceptualization, creating research instruments, guiding the research process, and writing articles, Viola Dwicha Asda and Andromeda; validating of students' worksheet, Yerimadesi and Hardeli.

Conflicts of Interest

The authors declare no conflict of interest.

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