The Effectiveness of Student Worksheet with Problem Based Learning and Ethnoscience to Improve Critical Thinking Skills on Chemical Bonding Material

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ABSTRACT

Learning chemistry through the merdeka curriculum prioritize on enhancing 21st century skills include students' critical thinking skills. Due to a number of critical thinking skill constraints, students find out the difficulties to comprehend theory-based in chemistry materials, such as chemical bonding materials. By problem-based learning that integrates ethnoscience content can make learning more meaningful is a way to train and enhance critical thinking skills. This research conducted in terms to quantify the effectiveness of Problem Based Learning and ethnoscience-based student worksheet on chemical bonding material to enhance the critical thinking skills of XI grade senior high school students. The research method used are descriptive quantitative and qualitative of One Group Pretest-Posttest Design. With 36 students of class XI-8 in SMAN 16 Surabaya as the subject, the worksheet stated effective according to the increasingly of N-gain value with an average of 0.7206 that is in the high category. As much as 26 students include into the high category, 8 fall into the medium category, and 2 fall into the low category.Therefore, the finding suggest that student worksheet with Problem Based Learning and ethnoscience-based student worksheet on chemical bonding materials can significantly improve students' critical thinking abilities.

Keywrods: Problem Based Learning, ethnoscience, critical thinking skills, chemical bonding.

INTRODUCTION

Chemistry is known as one of the subject areas in Senior High School which focuses on learning experiences and the development of process skills and scientific attitudes. Chemistry is a scientific field that focuses on the structure, composition, and properties of substances or materials from the microscopic scale to interactions in the formation of new compounds (Wulandari et al., 2018). Chemistry is delivered not only in the form of experiments or practicum, but also theory. One of the theory-based chemistry materials and the basis of students' understanding for further learning related to the style and shape of class XI molecules is chemical bonding material (Tsuroyya et al., 2022).

The Merdeka curriculum sets learning completeness criteria for students or known as Criteria for Achievement of Learning Objectives. The determination of that criteria is based on each education unit, criteria of 75, with classical completeness of 85%, this means that it is expected that a learning material is said to be complete if as many as 85% of students from that class get a score $\geq$ 75 on certain materials. In fact, in previous research at SMAN 1 Matauli Pandan by Siregar (2022) stated that the chemical learning outcomes of students on chemical bonding material obtained an average of only 75.23% which means it is classified as low and does not reach completeness. The incompleteness is caused by the characteristics of chemical bonding material that requires students to think critically (Yuzan & Jahro, 2022)

Chemical bonding materials have abstract and complex characteristics that require proof to be carried out through search activities and are equipped with the ability to investigate, analyze, and conclude the results of their search. The abstract part is in the sub-matter of electron release, acceptance, and transfer and the formation of bonds between elements or atoms

so that students have difficulty in understanding it. Therefore, skills such as critical thinking are needed for students who have links to investigation, analysis, and draw the conclusions. According to the Facione (2015) the indicators of critical thinking include interpretation, analysis, inference, evaluation, explanation, and self-regulation.

Based on preliminary research at SMAN 16 Surabaya using five essay questions, it shows that students have sufficient category in their critical thinking skills, those are in the interpretation indicator of 55.14%, analysis indicator of 42.64%, inference indicator of 41.91%, evaluation indicator of 50.21%, and explanation indicator of 69.12%. Due to the preliminary research findings, students' critical thinking abilities should be enhanced and trained.

One of learning models such as Problem Based Learning, which can develop students' critical thinking skills, is an alternate way to conquer this case. This learning model implements various activities such as scientific problem solving as the primary focus in order to make learning more meaningful, students have high motivation to learn, and enhance critical thinking skills (Suswati, 2021). Chemical bonding material through in-depth exploration can be related to everyday problems, besides that the connection between critical thinking abilities and Problem Based Learning are that through problem solving exercises, they will later use knowledge which has links to previous critical thinking indicators.

Critical thinking skills students will increase and enhance with Problem Based Learning model implementation on chemical bonding material while using an ethnoscience approach. The ethnoscience approach, provides a correlation between local science and scientific science so that it may easier for students to integrate science concepts into learning (Lia et al., 2016). Astari and Sumarni (2020) have conducted research on the creation of ethnoscience worksheet to enhance critical thinking abilities, obtaining a mean or average for the resulting N-gain value is 24.68%, this states an increase in critical thinking skills, as well as a student response of 54.80%, so that it state the worksheet is good. Manangkoda et al, (2023) conducted research related to utilizing of

the Problem Based Learning model with an ethnoscience approach to buffer solutions material, showing that student learning outcomes increased, where classical completeness was initially 74% to 96%.

Problem Based Learning as a learning model combined with ethnoscience approach can be implemented on media or learning tools. The preliminary questionnaire results at SMAN 16 Surabaya show that in learning chemistry, textbooks are still used with demonstrations and lecture methods, students feel that the devices used are less helpful in understanding chemical bonding material. Student worksheet as an alternative device and media for learning that can help improve the understanding of students integrated in a particular learning model. The development of a learning tool such as student worksheet must be appropriate the criteria so that it can be eligible to use and effective for increasing certain abilities and skills that should be improved.

According to the description of that background, the author will carry out research in title "The Effectiveness of Student Worksheet with Problem Based Learning and Ethnoscience to Improve Critical Thinking Skills on Chemical Bonding Material". It is anticipated that by integrating life and the environment into chemistry, the product will be able to enhance students' critical thinking abilities effectively so that it can be reconstructed into scientific knowledge integrated in worksheet as a learning tool in the classroom.

RESEARCH METHOD

The author was conducted research at SMAN 16 Surabaya with research subject of class XI-8 as mathematic and natural science class. The even semester of the 2024/2025 academic year was when the research was conducted. The methods of questionnaire, observation, and test will all be used to get the data. A validation sheet and a test sheet for critical thinking skills were used as the instruments.

Problem based Learning and ethnoscience-based student worksheet on the chemical bonding substance that had been created and approved by the validator were distributed to the research participants. Three qualified validators

those are two chemistry lecturers and a chemistry teacher with sheet of validation to assess the student worksheet and decide its validity.

The validation sheet contains content validity and construct validity which will be assessed using a Likert scale score. The decision making used is, student worksheet will be declared valid if it obtains a median of ≥4 with a valid category. The following is a table of Likert scale scores used by validators.

Table 1. Likert Scale Score

Score	Category
1	Bad
2	No enough good
3	Good enough
4	Good
5	Very good

(Adapted by Riduwan, 2015)

A One Group Pretest-Posttest Design was employed in the student worksheet trial with only a class as a comparison. The One Group Pretest-Posttest Design used will be explained in Table 2 below.

Table 2. One Group Pretest-Posttest Design

O_1	X	O_2

O_1 = pretest of students' critical thinking skills
X = application of student worksheet
O_2 = posttest of students' critical thinking skills

The class will be given a pretest and posttest before and after implementation of Problem Based Learning and ethnoscience-based student worksheet on chemical bonding material to determine its effectiveness in improving students' critical thinking skills. N-gain scores and statistical tests were used to examine the test results. The following is the formula of N-gain analysis.

$$\text{N-gain} = \frac{posttest\ score - pretest\ score}{100 - pretest\ score}$$

The outcomes of N-gain score then will be interpreted into several categories as in Table 3 below Interpretation (Hake, 1999).
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Table 3. N-gain Score Interpretation

Value Rank	Category
N-gain ≥ 0,7	High
0,3 < *N-gain* < 0,7	Medium
N-gain < 0,3	Low

According to the Hake (1999) that represent N-gain value in a range as can be seen at Table 2 above, if student get N-gain value ≥3, they are in medium to high category, therefore there's enhancing in the students' critical thinking abilities and said that the student worksheet applied before was effective.

RESULTS AND DISCUSSION

In this research, the research target is Problem Based Learning and ethnoscience-based student worksheet on chemical bonding material which was limited tested to 36 students in class XI-8 of SMAN 16 Surabaya.

Based on the observations and preliminary research results that have been conducted, it is known that learning activities are still fixated on the teacher centered learning method, this shows that learning models used and methods that are in line with the merdeka curriculum is not appropriate to make students proactive during learning and able to make them think critically. Preliminary research outcome using critical thinking skills tests also show critical thinking abilities of students are classified in the sufficient category. Due on the students' response questionnaire, 50% of students stated that it was difficult to understand theory-based material, one of which was chemical bonding material. This is caused by the less of support for the use of appropriate learning tools or media and the learning model used.

In this study, the average age of XI grade student is in range of 16-17 years, which students are at the formal operational stage in accordance with Piaget's theory of cognitive development so that can think more logically, abstractly, and idealistically. Learners are able to analyze a problem with systematic solution steps. The task that will be given in student are tailored to efforts to enhance learners' critical thinking skills and the merdeka curriculum.

In addition to containing learning resources about chemical bonding materials that are divided into three types, such as ionic, covalent, and metallic bonds, the student worksheet content focuses on Problem Based Learning activities that involve problems or phenomena relevant to ethnoscience. In addition to being text-rich, the learning resource has barcodes and YouTube links.

The design of Problem Based Learning and ethnoscience-based student worksheet on chemical bonding material media is printed out and preliminary format of the product developed so as to produce the worksheet draft as follows.
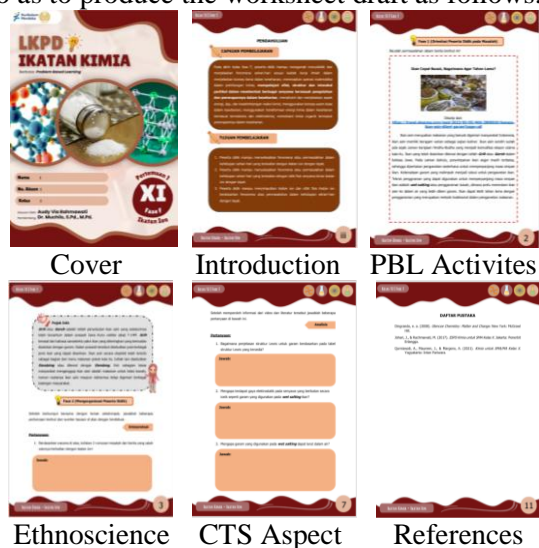

| Cover | Introduction | PBL Activites |
| Ethnoscience | CTS Aspect | References |

Figure 1. Initial Draft of Worksheet

There are three student worksheets developed, namely student worksheet 1 for ionic bonds, student worksheet 2 for covalent bonds and student worksheet 3 for metal bonds.

The validation of product and limited trials were carried out (Thiagarajan et al., 1974). The validation process is an evaluation that carried by two chemistry lecturers and one chemistry teacher on the products and instruments used in the research. Validity consists of content validity including the compatibility of the material in the student worksheet with learning objectives and Problem Based Learning model, and the accuracy of the material in the student worksheet, also the dimensions of skills in the student worksheet with critical thinking skills. While construct validity includes presentation, language, and graphics in the student worksheet. The following is a table of LKPD validation results.

Table 4. Student Worksheet Validation Results

Validity Criteria	Median		
	SW* 1	SW* 2	SW* 3
Content validity	5	5	5
Construct validity	5	5	5

*SW: Student worksheet

The student worksheet is stated valid according to the content validity and construct validity criteria based on the validation outcomes that were obtained with median that is 5. In content validity, a median of 5 indicates that the learning objectives and syntax of Problem Based Learning are correspondingly by the student worksheet that was developed, the student worksheet learning materials and correctness align with the chemical bond material and incorporate the phenomenon of chemical ethnoscience, additionally, the student worksheet skill dimensions align with indicators of critical thinking skills. While construct validity, the median is 5 shows that student worksheet developed is in align with the aspects for good presentation, language, and graphics. Therefore, the student worksheet can be tested in limited of students depending on the validation results.

Pretest and posttest result will be used for decide the effectiveness of student worksheet that can impress critical thinking skills. To identify the existence of enhance in critical thinking abilities of student after implementing Problem Based Learning and ethnoscience-based student worksheet on chemical bonding material, the N-gain test and statistical tests were carried out. The Table 5 below is the acquisition of students' N-gain score.

Table 5. Critical Thinking Skills N-gain Score

Num.	Name	N-*gain*	category
1.	AA	0,94	High
2.	AQA	0,87	High
3.	AHPI	0,62	Medium
4.	AMSA	0,50	Medium
5.	AAA	0,71	High
6.	ARK	0,89	High
7.	AR	0,90	High
8.	AKAP	0,43	Medium
9.	AJAMF	0,91	High
10.	ASPA	1,00	High
11.	BAZ	0,93	High
12.	DAS	0,39	Medium
13.	DNSI	0,89	High
14.	GAPY	0,25	Low

Num.	Name	N-*gain*	category
15.	HEH	0,77	High
16.	HS	0,56	High
17.	HA	0,90	High
18.	IRJI	0,83	High
19.	JAAW	0,77	High
20.	KAA	0,71	High
21.	NNP	0,69	High
22.	NZH	0,64	Medium
23.	NSA	0,92	High
24.	NSS	0,69	High
25.	NWH	0,60	Medium
26.	ONF	0,50	Medium
27.	OMF	0,88	High
28.	RAT	0,62	High
29.	RAI	0,32	Medium
30.	RAH	0,60	High
31.	SSW	1,00	High
32.	SCPR	0,68	High
33.	SAA	0,89	High
34.	YAP	1,00	High
35.	ZAAS	0,27	Low
36.	ZAS	0,87	High

Based on the table data, the N-gain score for pretest and posttest is, up to 26 students include into the high category, 8 fall into the medium category, and 2 fall into the low category. Students in the high and medium N-Gain groups receive training in their critical thinking skills on a number of tested indicators. They can also interpret the meaning of a phenomenon or problem that includes ethnoscience in the material on chemical bonds, formulate a continuous hypothesis, analyze the problem by adjusting it to the knowledge that has been obtained, assess the veracity of statements, and provide conclusions on the problem or ethnoscience phenomenon of chemical bonds along with pertinent justifications. While the students with low N-gain score. are known to have not been able to applying a number of several indicators of critical thinking well when working on test questions. This is triggered by several factors including the seriousness of students in approach on the test and lack of understanding during the test and when learning using student worksheets.

The obtained result support that the developed student worksheet can help in enhancing and trained critical thinking skills in students. The N-gain score result also presented in pie diagram below.
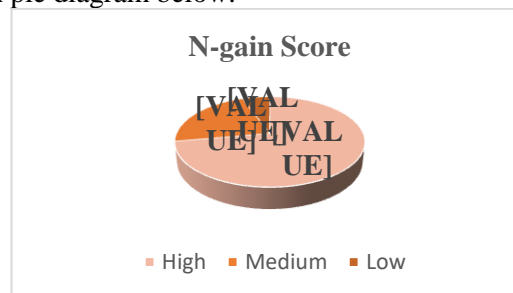

Figure 2. N-gain Score of Students

The mean of N-gain score on the students' pretest and posttest was calculated using the IBM SPSS Statistics 25 application, with the average score presented in the Table 6.

Table 6. N-gain Score Average

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Ngain	36	.25	1.00	.7206	.21385
Valid N (listwise)	36				

Due to the table, It is well known that the mean of N-gain score is 0,7206 which means ≥0,7 so that it is in the high category (Hake, 1999). While each critical thinking indicator also has N-gain score that will be shown in the Table 7.

Table 7. N-gain Score of Critical Thinking Indicators

Num.	Indicators	N-gain	Category
1.	Interpretation	0,66	Medium
2.	Analysis	0,63	Medium
3.	Evaluation	0,80	High
4.	Inference	0,78	High

In the table, it is known that the N-gain from indicators of critical thinking skills fall between the medium and high range, this indicates that developed student worksheet is effective for enhancing critical thinking abilities and skills of students.

According to Facione (2015), in each indicator of critical thinking skills, there are sub-skills that can be trained to students. In the interpretation indicator, students are able to interpret statements, categorize, and formulate problems accompanied by hypotheses. The

analysis indicator train students to identify the relationship between questions and the concepts taught. Evaluations carried out by students include assessing and estimating the truth of statements accompanied by reasons according to the concept. And in the inference indicator, students can draw logical conclusions from statements and provide evidence for the hypotheses made.

The effectiveness above is suitable with previous research by Yulfiani and Muchlis (2021) that the student worksheet with the Problem Based Learning model can make students' critical thinking skills enhanced. In addition, the ethnoscience phenomenon raised in student worksheet can add insight and knowledge to students and make students understand learning materials easier.

CONCLUSION

Based on the research, N-gain score due to pretest and posttest, N-gain score average, and N-gain score of critical thinking skills indicator indicate that Problem Based Learning and ethnoscience-based student worksheet are effective for improving critical thinking skills of students on chemical bonding material.

The suggestion for further research is expected to implement Problem Based Learning and ethnoscience-based student worksheet on a wider scale so that its effectiveness can be known to improve critical thinking skills. The application in control and experimental classes will strengthen the effectiveness of the media developed. During the research there were time limitations in implementation and learning, so it is necessary to reconsider the learning hours used so that it can be implemented optimally. Improvement of student worksheet is needed by adjusting to the environment and characteristics of students

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