

DEVELOPMENT OF STUDENT WORKSHEET ON ACID BASE MATTER BASED ON CHEMISTRY REPRESENTATION AND CHEMISTRY LITERACY TO TRAIN STUDENT CRITICAL THINKING SKILL FOR SENIOR HIGH SCHOOL GRADE XI

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Abstract

This study purposed to describe feasibility of student worksheet based on chemistry representation and chemistry literacy to train student critical thinking skills on acid base matter. This study used research and development method according to ADDIE model. Step of ADDIE model includes analysis, design, development, implementation, and evaluation. The instrument of this study used student worksheet assessment, quality student worksheet assessment, critical thinking test, student questionnaire and activity observation sheets. The subject of this study consist of chemistry lecturer, one chemistry teacher and 15 students grade XI of SMA Khadijah which chosen heterogeneously. The results showed that (1) Student worksheet was developed that evaluated on feasibility category with average percentage of contents, presentation, graphic and linguistic respectively 90,86% (very feasible), 90,34% (very feasible), 91,66% (very feasible) and 91,11% (very feasible). (2) Student critical thinking skills of worksheet on each indicator perspective obtained between 77,6% – 95,6% on interpretation, 78,66% - 89,3% on analysis, 79,1% - 92% on evaluation, 66,67% - 82,6% on explanation and 81,33% - 94,6% on inference indicator. (3) Student respon obtained percentage between 80% - 91,67% in very good category, its supported by relevant student activity (critical thinking) between 96,67% - 98,67%. It showed that student's critical thinking skills in every indicator on critical until very critical category. Based on the data result indicate that worksheet is declared feasible to trill critical thinking skill to material of acid-base theory.

keywords: chemistry representation, chemistry literacy, critical thinking skills, acid base theory.

INTRODUCTION

Globalization era demands the advancement of various fields, politiceconomic, social, culture religious, technology, and education. Globalization affects various fields, especially in the acquisition of per capita income. Indonesian has a lot of natural resources that can be processed become product. The natural resources isn't being used maximally, it caused by the lack of student ability to utilize natural resources that needs to be processed through education.

Education is conscious and planned as effort to create an atmosphere of learning and learning process, so that students are actively carrying the tension of themselves to have spiritual power, self-control personality, intelligence, morality, skills that required by student, society, nation and state [1]. Through education, student be innovative and flexible competitive person to face globalization era. Indonesia government support it by designing curriculum based on active learning. It becomes an education goal through lesson planning, learning implementation and learning assessment to increase efficiency and effectiveness of student competency achievement [2].

The competency can achieved by student using contructivist learning. The learning will occurred elaboration and integration to construct knowledge until appear scheme in brain. The scheme that formed is high order thinking process is critical thinking. Critical thinking skill can achieved by student through these activities: observing, questioning, trying, reasoning, serving, and creating [3].

Critical Thinking skill activites can be applied to solve sequential problems. Facione's (2013) declare critical thinking skills consist of several interpretation, evaluation, analyze, inference, explanation and self-regulation [4]. It done by students through the process of thinking and he tunderstanding regularity of concept actively. This opinion supported by Johnstone, that declare the rugalrity of conceptual understanding can hone the skill of thinking critically based on the concept representation [5]. Those representation are symbolic, sub-microscopic, and macroscopic.

Representation of the concept isn't fully applied to the learning process. It according to Gabel's opinion that declare teachers tend to teach only symbolic levels or macroscopic and symbolic

[6]. The ability of student to understanding the concept can be said limited, therefore it's necessary for the role of educator to facilitate their understanding of a regular concept. The concept understanding will facilitate their critical thinking skills. Based on this, it is necessary to have structured learning designed by educators.

Prasetyowati and Suyanto (2016) stated that educators can transfer information through learning tools systematically [7]. The learning tools used to convey materials are based on the regularity of chemistry representation concept that presented in accordance with chemistry literacy. Preparation of representation is a form of multi-representation to repeat the concept with different forms, aims to correlate between concepts in a material. Systematic device problem contain of problem based on daily life. Student can understand the concept regularly and actively to looking for problem solving through the daily phenomenon.

Problem based learning criteria are an important component to trained critical thinking skills. The component, presented in the form of teaching materials based on chemistry representation and chemistry literacy worksheet student. Chemistry representation used as basis of worksheet preparation, consists of macroscopic, sub-microscopic, and symbolic representation. Chemistry literacy role as activating the concept that the student has solved problem. The components of chemistry literacy that used are content, procedural, and epistemic knowledge. The implementation of chemistry literacy and chemistry representation is a directive structured used in worksheet to trained pattern of critical thinking, so generated critical thinking skills.

The basic relationship of chemistry representation, chemistry literacy and critical thinking is viewed from each skill component that emerges based on chemistry representations and chemistry literacy, so it create the desired critical thinking skills. Chittle borough and Treagust state that chemistry representation is the ability of student to plot concepts according to their individual characteristics [8]. Accordingly, students are actively requires to solve problems to understanding concept that being build. Thus, a basic chemistry literacy is required as the embodiment of the use of concepts, theories, practices in conducting scientific inquiry [9].

It can delivery through delivering on worksheet that commonly used in learning process containing limited critical thinking skills assignment and reflect one or two representations. This is evidenced by the type of question for example is

"HCl decomposes into ions..." The next question is "Then, the substance (HCl) is called..." and following with the definition of acid or base assignment that completing example. Meanwhile, international worksheet student on acid base matter presented symbolic and sub-microscopic assignment. Mark and Pavio (2001) state that the comprehensive conceptual achieved by student through their ability to processing information based on double representations [10]. Based on this, it is necessary to having worksheet based on chemistry literacy and chemistry representation to train critical thinking skills.

It can be used as solution in understanding of chemistry matter especially acid-base. Sheppard (2006) argues that the acid-base is a conceptually dense material and requires an understanding that is integrated into some chemistry introduction concepts such as particle characteristics in matter, the properties and composition of solutions, atomic structures, ionic and covalent bonds, symbols, formulas and reaction equations, ionization as well as equilibrium [11]. This supported by low result of critical thinking skills on acid base matter conducted by Puspitasari (2017) states the critical thinking on interpretation indicator only obtained 2.84 from 4 scale [12]. Based on these problem, chemistry representation and literacy chemistry worksheet can be used to train critical thinking skills.

METHOD

This research is a development research to develop student worksheet based on chemistry representation and chemistry literacy to train critical thinking skill. The steps of this study refers to ADDIE model are analysis, design, development, implementation and evaluation. It only limited on formative evaluation.

On the design phase is produced worksheet device according the components of critical thinking skills, chemistry representation and chemistry literacy. Furthermore, a formative evaluation was undertaken at the design phase in the form of worksheet assessment by one chemistry lecturer who giving attention to each component on tasks that presented. This evaluation, conducted to produce worksheet that according with the advice of reviewer.

The worksheet that have been produced will assessed by two chemistry lectures and one chemistry teacher on formative evaluation in develop phase. The device which assessed are worksheet, lesson plan, student response, critical thinking test, and student observation sheet. Quality

assessment based on content, presentation, graphic and linguistic using Likert scale such Table 1 [13].

Table 1 Likert Scale

Assesment	Scale
Very Unfasible	1
Less Feasible	2
Quite Feasible	3
Feasible	4
Very Feasible	5

The results obtained were analyzed by quantitative descriptive. The results of descriptive analysis are interpreted in table 2 to determine the feasibility of worksheet [13].

Table 2 Interpretation of Score Criteria

Presentage (%)	Criteria
0 - 20	Very Unfasible
21 - 40	Less Feasible
41 - 60	Quite Feasible
61 - 80	Feasible
81 - 100	Very Feasible

After worksheet is declared feasible, then carried out small-scale implementation of it. Implementation was conducted on 15 students of grade XI IPA SMA Khadijah Surabaya which was chosen heterogeneously. The final result of implementation is critical thinking skills data based on the acquisition of critical skills test scores.

The critical thinking skill instrument score is used to know each critical thinking component in percentage form using the following formula.

$$\text{Component values} = \frac{\sum \text{obtained score}}{\sum \text{total score}} \times 100$$

The result of component analysis critical thinking skill is interpreted in category on Table 3 [13].

Table 3. Interpretation Critical Thinking Skill

Percentage (%)	Category
0 - 20	Uncritical
21 - 40	Less Critical
41 - 60	Quite Critical
61 - 80	Critical
81 - 100	Very Critical

The result of critical thinking skill assessment is stated to increase after using worksheet based on Wilcoxon matched pairs test result using SPSS 16. The criteria used to reject or accept student worksheet related hypotheses can trace critical thinking skills based on Asymp Sig value in the SPSS program where:

If *Asymp. Sig* < α so H_0 rejected

If *Asymp. Sig* > α so H_a accepted

Description:

H_0 : there is no effect of improving critical thinking skills.

H_a : There is an influence on improving critical thinking skills.

Analysis of student response is done to describe the practicality of worksheet to drill critical thinking skill reviewed based on student response questionnaire. Questionnaire response is presented in the form of statements with "yes" and "no" answers based on the Gutmann scale in Table 4 [13].

Table 4 Gutmann Scale Criteria

Answer	Score
Yes	1
No	0

Response analysis is declared relevant while observational activity result percentage $\geq 61\%$. Activity observation was done every 3 minute by one observer in one group.

RESULT AND DISCUSSION

The result of study and discussion on worksheet development based on chemistry representation and chemistry literacy are analyses as follow.

Validity Result of Student Worksheet

The results of validity student worksheet are obtained based on the quality assessment conducted by two chemistry lectures and one chemistry teacher as follows.

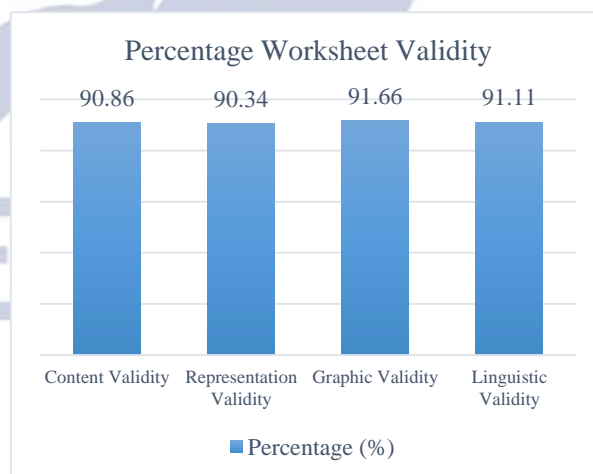


Figure 1 Result of Quality Assesment Student Worksheet

Based on the results of student worksheet quality assessment obtained an average of 90,99% with very feasible criteria. The component that evaluated on content criteria are chemistry representation, chemistry literacy, critical thinking

and learning objective that used. Chemistry representation on this worksheet obtained percentage between 86,1%-92,49% on macroscopic, 87%-91,11% on sub-microscopic, and 100% on sub-microscopic-symbolic representation. The representation that valued by validator are identification of phenomenon as macroscopic, invisible concept of acid base assignment as sub-microscopic and illustration of molecule that showed as sub-microscopic-symbolic representation to show reaction that occurred.

Second, chemistry literacy obtained percentage between 86,67%-95% on content, 88,89%-93,33% on procedural and 83,33%-93,33% on epistemic knowledge. The literacy chemistry that valued by validator are identification of phenomenon and concept of acid base matter as content, determine of observation procedure and write the result as procedure and determine claim to solve or identification caused of phenomenon as epistemic knowledge.

Third, critical thinking component obtained percentage between 93,33%-100% on interpretation, 86%-92% on analysis, 86,67%-93,33% on evaluation, 86,66%-90% on explanation and 93,33% on inference indicator. Fourth, learning objective obtained percentage between 86,67%-96,66%. All description showed that student worksheet based on chemistry representation and chemistry literacy declared feasible to be used as learning device.

Result of Observation Activity and Student Response

The data of observation activity is done by five observer using instrument assessment observation activity student during small implementation. The result of analysis observation activity showed below.

Table 5 Result of Observation Activity Student

No	Implementation	Percentage Activity (%)	
		Relevant	Irrelevant
1	One	96,67	3,33
2	Second	98,00	2,00
3	Third	98,67	1,33

Furthermore, a student response questionnaire filled by students is used to support practicality of the developed student worksheet. The student questionnaire response was filled by 15 students of SMA Khadijah heterogonously. Student will value about content, presentation and linguistic criteria of worksheet kindly and without coercion

from other parties. The data of student response questionnaire is obtained as follows.

Table 6 Result of Quistionnare Student Responce

No	Aspect	Percentage (%)	Category
1	Content	91,67	Very Good
2	Presentation	88,89	Very Good
3	Linguistic	80	Good

Analysis Result of Critical Thinking Skills

The analysis result of each indicator of critical thinking skill is shown in the following figure.

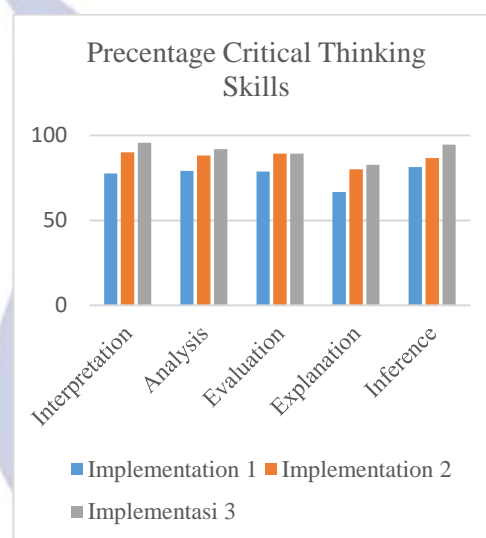


Figure 2 Percentage Critical Thinking Each Indicators

The data in figure 2 is the average value of each component that trained on small implementation. The indicator of interpretation skills for each implementation respectively obtained percentage 77,6%, 90%, and 95,6% were on critical until very critical category. Where the assignment of students is to identify problems and to identify the phenomenon that is faced through various forms of complex considerations. This, according to Cotrell (2005) states that critical thinking skills are obtained through complex considerations involving attitudes and skills [14].

The analysis indicator respectively obtained percentage 79,1%, 88,2%, and 92% were on critical until very critical category. The type assignment is to determine the procedure of investigation, to assess the data, and to write down the reaction. Trained components require the role of chemistry representation and chemistry literacy to write their ideas in completing critical thinking skill tasks.

The information obtained by students on the type of assignment analysis is implementation of dual coding theory information processing which states that information is more easily processed through the mental processes of the two linked systems [10]. The two systems are presented in the form of macroscopic-sub-microscopic or sub-microscopic-symbolic representations.

The evaluation indicator respectively obtained percentage 78,66%, 89,3%, and 89,3% were on critical until very critical category. The trained component is to estimate the credibility of acid and base properties of a substance presented in tabular form. The information contains all chemistry representations. Students can use the idea of knowledge in the content domain on chemistry literacy, as it relates to the permanent concept acid and base theory.

The explanation indicator respectively obtained percentage 66,67%, 80%, and 82,6% were on critical until very critical category. The percentage is relatively small if compared with other indicators, because students have difficulty in transforming macroscopic representation with sub-microscopic. The type of assignment that is presented dominant in the activity of assessing the truth of an idea that related to everyday phenomena is supported with the concept that students have about acid-base theory. In this skill, students are required to actively transform the representation by using information on their long-term memory. Suyono and Hariyanto (2015) stated that information on long-term memory would be used if recalled [15]. Based on this, students actively process information in the brain.

The inference indicator respectively obtained percentage 81,3%, 86,6%, and 94,6% were on very critical category. The type of assignment is make a conclusion relating to the acid-base theory. Where there is a transformation of representation into a conclusion. It according to Kozma and Russell (1997) argues about the ability to write one representation to write different representations [16].

The overall data about critical thinking final test result showed that student on category critical until very critical. Skill enhancement occurred by implementation of student worksheet based on chemistry representation and chemistry literacy on acid-base theory. It supported by the results of Wilcoxon test data analysis matched pair test using SPSS 16 with the following results.

The significance level (α) that used for the 15 data is 0.05. Analysis results of every implementation respectively have Asymp.Sig value

0.001. It can be concluded that $\text{Asymp.Sig} < \alpha$ (0.001 < 0.05), then H_0 is rejected [17]. It shows that implementation of student worksheet based on chemistry representation and chemistry literacy give influence to the improvement of critical thinking skill.

CLOSURE

Conclusion

Based on the results of research and discussion of student worksheet based on chemistry representation and chemistry literacy on acid base concept is said to be feasible with description as follows. The result of quality assessment of student worksheet 1 (Arrhenius acid-base theory), student worksheet 2 (Bronsted-Lowry acid base theory, and student worksheet 3 (Lewis acid acid theory) obtained the average percentage of content of 90,86%, presentation of 90,34 %, graphic of 91,66% and the linguistic criteria of 91,11% is on very valid / feasible category. On content criteria based on representation chemistry component obtained average percentage 93,18% and chemistry literacy obtained average percentage 90,59%. It means all of criteria had been fulfilled criteria of validity.

The mean value of critical thinking on interpretation is 87,73%, 86,43% on analysis, 85,7% on evaluation, 76,4% on explanation, and 87,5% on inference. Indicators of critical thinking skills of explanation are on critical category, whereas in the indicators of interpretation, analysis, evaluation, and inference are on very critical category. It supported by Wilcoxon test analysis results obtained $\text{Asymp.Sig} < \alpha$ (0.001 < 0.05), so H_0 is rejected. It means student worksheet declared effective for train critical thinking skills.

Student response obtained average percentage on aspect of content equal to 91,67%, presentation aspect 88,89%, and language aspect equal to 80%. The acquisition of students' responses is relevant to the average percentage of activity observation of 97.78%. Based on this, it is shown that the developed student worksheet had been fulfilled criteria of practicality.

Suggestion

Based on students response about the language aspects in student worksheet, there are uncommunicative language. Researcher suggest to pay more attention to the preparation of student worksheet in language terms. In the implementation of student worksheet, on introduction of the concept through the phenomenon students should be actively read to maximize learning time. Researcher suggest

to ask student reading text on worksheet completely before do the task.

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