



Feasibility of Worksheet Based on PBL to Improve Students' Critical Thinking Skills on Acid-Base Material

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ABSTRACT .

Critical thinking skills are important for students to improve in facing the challenges of the 21st century. One of the way to improve critical thingking skills is by using relevant learning media, namely student worksheet (LKPD) based on problem based learning (PBL) model. The purpose of this research is to obtain a worksheet based on PBL to improve critical thinking skills on acid-base material. The feasibility of the worksheet is reviewed from the aspects of validity, practicality and effectiveness. The method use in this research is R&D with 4D model, but only reached the develop. The subjects of this research amounted to 15 students of SMAN 7 Surabaya. The research results showed that the worksheet was declared valid in terms of the mode score of content validity of 5 with a very valid category, and construct validity of 4 with a valid category. The practicality of worksheet is seen from the results of the student response questionnaire, namely that students respond positively to the use of worksheet based on PBL to improve critical thinking skills and is supported by the results of observing that students' relevant activities are greater than irrelevant activities. The effectiveness of worksheet in terms of the results of students' critical thinking skills tests has improved with N-Gain scores in the range of 0.59 – 1.00 in the medium and high categories. And supported by the results of knowledge tests where all students have achieved individual mastery with a score of ≥ 75 .

INTRODUCTION

Chemistry is a field of science that studies the properties, structure, and reactions of particles (Artini & Wijaya, 2020). In chemistry learning, students are expected to be able to develop their skills in line with the skills needed in the 21st century. In the 21st century, education does not only focus on improving hard skills but also on improving soft skills, which include the ability to learn and innovate, use technology and information media, and life skills (Directorate General of Primary and Secondary Education, 2017). According to Putriani and Hudaidah (2021), there are three primary skills in the 21st century, namely the skills to reason, act, and live in the world. Reasoning skills include critical, creative reasoning, and problem-solving. Action skills include communication and literacy. Meanwhile, life skills in the world include initiative, self-control, global insight, and social responsibility. According to

Wijaya et al. (2016), the skills taught in 21st-century education are known as the 4C, namely critical thinking, creativity, collaboration, and communication. Critical thinking skills are one of the skills that really need to be developed in order for students to have more focused reasoning abilities, solve problems around them, and prepare them to face challenges in the future (Karakoc, 2016).

The indicators of critical thinking, according to Facione (2015), include interpretation, inference, analysis, evaluation, explanation, and self-regulation. These components are similar to the 21st-century learning requirements contained in the graduate competency standards (SKL). According to the Ministry of Education and Culture (2016), high school graduates should have the skills to reason and act creatively, critically, independently, cooperatively, and communicatively as an extension of what they have learned in the education unit. One of the materials in chemistry lessons that requires a high level of understanding is acid and base. Acids and bases are quite complex materials because they are related to concepts, memorization, calculations, and their application in everyday life. Critical thinking skills in the acid-base chapter are still relatively low. This is proven by the results of pre-research carried out in January 2024, where the percentage of students' critical thinking skills as a whole is 15%; if reviewed per critical thinking indicator, then the percentage of interpretation is 13%, analysis 25%, explanation 13% and inference 11%.

One of the causes of the low critical thinking skills of students at SMAN 7 Surabaya is ineffective teaching and learning activities. This is because the learning media and questions used during the chemistry learning process and during tests have not been able to train critical thinking skills. Of course, students really need the role of the teacher to achieve success in this material. One of the things that can support successful learning is the selection of learning methods and models that are in line with the needs and characteristics of students. An appropriate and student-centered learning model is needed to improve students' critical thinking skills. Learning models can be interpreted as patterns to be used as a guide in planning learning in the classroom (Suprijono, 2010).

One of the learning models that can improve critical thinking and apply a student-centered approach is problem-based learning (PBL). PBL is a learning model that implies the presentation of meaningful situations that function as students' investigation of a problem (Arends, 2008). In PBL, problems are given that help to gain new understanding, form thinking skills, and solve problems so that students can learn independently (Wati & Yuliani, 2020). The PBL model consists of 5 learning syntaxes, namely (1) orienting students to the problems, (2) organizing students in learning, (3) helping students individually or in groups in carrying out investigations, (4) developing and presenting the results of their work, (5) analyzing and evaluating of the problem-solving process (Arends, 2008).

The relationship between critical thinking and the PBL model is reflected in each learning syntax. In the first syntax, students will identify and formulate problems; that's when the critical thinking activity of interpretation will appear. The second syntax is that students carry out a literature review, then answer questions and discuss the problem-solving process; at that time, critical thinking activities of explanation and interpretation will appear. The third syntax is that students carry out experiments and formulate hypotheses, and then critical thinking activities, interpretation, and analysis will appear. In the fourth syntax, students write down experimental results, analyze data, and make conclusions; at that time, critical thinking activities of analysis, explanation, and inference will appear. In the last syntax, students analyze and evaluate problem-solving, at that time, critical thinking activities of analysis will appear.

The advantages of the PBL model include that it can motivate students, increase learning activities, and make it easier for students to master the concepts learned in order to solve real-world problems (Sanjaya, 2013). The PBL model also has several shortcomings in its application, one of which is that the success of learning strategies carried out through PBL requires quite a long time to prepare. To overcome these shortcomings and support the learning process, appropriate learning media is needed, namely worksheets. Worksheets contain tasks that must be done to conduct research or solve problems in order to develop cognitive aspects and other learning aspects. They contain instructions on how to complete tasks based on the underlying competencies (Riyadi, 2018). Worksheets can make it easier for students to understand and deepen the material content of the lessons being taught; teachers can prepare worksheets according to the material being taught.

The National Standards Agency (BSNP, 2012) explained that several aspects must be included in the development of a worksheet, including the feasibility of content, language, presentation, and graphics. According to Yuniarti et al. (2014), a good learning instrument must be valid, practical, and effective. The instrument is declared valid if it meets the criteria of content and construct validity. It is stated to be practical if it is easy to use and obtained from student responses, and it is said to be effective if the activity process meets the final goals and objectives of the activity being carried out. Based on the explanation, the author conducted research entitled "Feasibility of Worksheet based on PBL to Improve Students' Critical Thinking Skills on Acid and Base Material" to develop worksheets that were considered feasible in improving students' critical thinking skills in terms of validity, effectiveness, and practicality.

RESEARCH METHODS

Research Approach

This type of research is Research and Development with Thiagarajan 4D development design, which consists of four stages: Define, Design, Develop, and Disseminate. However, this research only reached the development stage of limited trials.

Research Participants

There are two sources of data in this research. First, validation data was obtained from 2 chemistry lecturers and 1 chemistry teacher. Second, limited trial data was obtained from 15 students with heterogeneous cognitive abilities.

Research Instrument

The instruments used in this research consisted of:

- a) The Validation Sheet contains statements or criteria for the feasibility of worksheet as seen from content and construct validity. On this sheet there is an assessment column to be filled in by the validator.
- b) The student response questionnaire sheet contains statements that aim to obtain student responses to learning by using the developed worksheet. This questionnaire sheet consists of positive questions and negative questions along with the answer options "Yes" and "No".
- c) The student activity observation sheet contains statements of student activity, either relevant or irrelevant, every 3 minutes, which are presented in table form.
- d) The critical thinking skills test sheet consists of 3 essay questions that have been adapted to the indicators of critical thinking skills (interpretation, explanation, analysis and inference)
- e) The knowledge test sheet contains 10 multiple-choice questions related to acid-base material.

Data Collection

Questionnaire Method

The Questionnaire method consists of a validation sheet and a student response sheet. On the validation sheet, the questionnaire was filled out by validators consisting of two lecturer from chemistry education study and one chemistry teacher. The validator in charge of filling in the validation questionnaire sheet by writing the scores in the question item column provided. While on the student response sheet, Students fill out the questionnaire sheet by giving a check mark (✓) in the "Yes" column if the criteria listed are appropriate, and "No" if the criteria listed are not appropriate.

Observation Method

Observations were carried out during the learning process using observation sheets to observe and record the implementation of learning in class using worksheet based on PBL. There are 3 observers on duty. Observers will observe and then fill in the observation sheet by giving a check mark (✓) in the time column in the appropriate aspect as observed.

Test Method

There are two types of tests in this research, namely critical thinking skills tests and knowledge tests. The critical thinking skills test consists of two test stages, namely a pretest given at the beginning of the learning activity to determine the initial critical thinking skills of students before using the developed worksheet and a posttest given at the end of the learning activity to determine the improvement of students' critical thinking skills after using the developed worksheet. For the knowledge test given after using the developed worksheet to determine the learning outcomes based on the completeness of the student's scores.

Data Analysis

1. Validation Data Analysis

The data was analyzed based on the scores given by validators. Each validator gave a score on each aspect according to a likert scale as shown in Table 1.

Table 1. Likert Scale

Category	Scale Value
Very Valid	5
Valid	4
Fairly Valid	3
Less Valid	2
Very Invalid	1

Based on Table 1. The developed worksheet can be said to be valid if the mode value is the range ≥ 4 with valid and very valid criteria.

2. Response Questionnaire Data Analysis

Student responses were measured using a Guttman scale, which is a scale used for clear and consistent answer as describe in Table 2.

Table 2. Guttman Scale

Question	Answer	Value/score
Positive	Yes	1
	No	0
Negative	Yes	0
	No	1

The data obtained will be analyzed using the following formula.

$$\% = \frac{\sum \text{score obtained}}{\sum \text{Maximum score}} \times 100\%$$

Then the percentage results will be interpreted into the following score.

Table 3. Interpretation of Practically Score

Percentage (%)	Criteria
0 – 20	Impractical
21 – 40	Less Pratical
41 – 60	Quite Practical
61 – 80	Praktical
81 – 100	Very Practical

(Riduwan , 2015)

Worksheet is said to be practical if the value obtained is $\geq 61\%$ with practical and very practical criteria.

3. Data Analysis of Observation of Student Activities

This data was analyzed descriptively quantitatively. The calculation formula used is as follows:

$$\% \text{Relevant student activities} = \frac{\sum \text{the time of relevant activity that occurs}}{\sum \text{total time}} \times 100\%$$

Student activities are said to be well implemented if the percentage of relevant student activities is greater than irrelevant student activities.

4. Critical thinking skill test data analysis

The results of students' pretest and posttest work were analyzed by giving a maximum score of 10 for on each indicator of critical thinking skills. Then the scores will be interpreted into grades using the following formula.

$$Value = \frac{\sum score\ obtained}{\sum maximum\ score} \times 100$$

After knowing the pretest and posttest scores, then calculate the $\langle g \rangle$ value to determine the increase in students' critical thinking skills after using the worksheet was developed using the following equation:

$$\langle g \rangle = \frac{value\ Posttest - value\ Pretest}{maximum\ value - value\ Pretest}$$

The criteria for the value of the N-Gain Score results can be seen in the following table :

Tabel 4. N-Gain Score Criteria

<i>N-Gain Score Result</i>	Criteria
$g < 0,30$	Low
$0,70 \geq g \geq 0,30$	Medium
$g > 0,70$	High

(Hake,1999)

The worksheet developed is said to be effective if the N-Gain score is at least 0.3 with medium and high criteria.

5. Knowledge Test Data Analysis

The knowledge test was analyzed by finding individual completeness, the following formula is used.

$$Individual\ completeness = \frac{\sum score\ obtained}{\sum maximum\ score} \times 100$$

Students are said to be complete if they have reached the minimum score ≥ 75 .

RESULTS AND DISCUSSION

Validity Result of Worksheet Based on PBL

The validation stage aims to obtain an assessment of the worksheet product developed. Data from the validation results of the worksheet developed can be seen in Table 5.

Tabel 5. Results of Worksheet Validation

Validity	Mode	Category
Content	5	Very Valid
Construct :		
1. Presentation	4	Valid
2. Language	5	Very Valid
3. Graphics	4	Valid

Based on Table 5, it is known that the worksheet can be said to be valid in terms of content validity, obtaining a mode value of 5 with Very Valid criteria. As for construct validity includes

presentation which obtained mode 4 with valid category, language obtained mode 5 in the very valid category, and graphics obtained mode 4 with a valid category.

Practical Result of Worksheet Based on PBL

1. Student Response Questionnaire

The results of the student response questionnaire can be seen in Table 6.

Tabel 6. Result of the student response questionnaire

No	Statement	Percentage	Category
A	LKPD		
1.	The worksheet used is arranged systematically	100%	Very Practical
2.	The appearance of the worksheet used is interesting.	93%	Very Practical
3.*	Instructions for using worksheet are not clearly stated.	87%	Very Practical
4.*	The use of language in the worksheet is difficult to understand	87%	Very Practical
5.	Using font types, and sizes makes it easier for you to use the worksheet.	100%	Very Practical
B	Learning Activities		
6.	The learning activities carried out can motivate me in studying acid-base material.	93%	Very Practical
7.	The learning model used can make it easier to learn acids and bases	93%	Very Practical
8.*	The activity steps in the worksheet used made me passive during the learning process	87%	Very Practical
9.	Exercise questions contained in the worksheet can improve my ability to think critically	100%	Very Practical
10.	The activities in the worksheet used can train me in discussing with my friends or group to find the right answer.	100%	Very Practical
Average		95%	Very Practical

* : for negative statements

Based on Table 6, it can be seen that the results of the student response questionnaire to the use of worksheet based on PBL as a whole obtained an average percentage value of 95% with very practical category (Riduwan, 2015). This means that the use of the worksheet based on PBL developed can be said to be very practical to improve students' critical thinking skills in acid-base material.

2. Observation of Student Activity

The results of the observation of students activities are presents in Tabel 7.

Tabel 7. Result of Observation of Students Activities

No	Student Activity	Percentage of Observation Result			Average
		Meeting 1	Meeting 2	Meeting 3	
1	Relevant	88,89 %	93,33%	95,56%	92,6%
2	Irrelevant	11,11%	6,67%	4.44%	7,4%

Based on the table above, it is known that the average percentage of relevant student activity during the trial was 92.6%. So it can be said that during the trial using the worksheets developed, students were very enthusiastic about participating in the learning.

Effectiveness Research Result

1. Critical Thinking Skills

The following is data on the N-Gain score results from the students' critical thinking skills test on acid-base material.

Tabel 8. N-Gain Score

Student	N-Gain	Category
1	0,91	High
2	0,91	High
3	0,96	High
4	0,63	Medium
5	0,85	High
6	1,00	High
7	0,65	Medium
8	0,59	Medium
9	0,75	High
10	0,91	High
11	0,78	High
12	0,59	Medium
13	0,77	High
14	1,00	High
15	0,87	High

Based on the table above, it can be seen that 11 students got an N-Gain score ≥ 0.70 With high category, and 4 students got an N-Gain score of $0.3 < (g) < 0.7$ with a medium category.

2. Knowledge Test

This test is used as supporting data in analyzing the effectiveness of the worksheet based on PBL being developed. This test contains 10 multiple choice questions. The following are the results of the student knowledge test.

Table 9. Recapitulation of Knowledge Test Results

Value	Score Number of Students
≤ 69	-
70 – 79	-
80 – 89	4
90 – 100	11

Based on the table 9, it can be seen that all students can be said to be complete because they have met the predetermined individual completeness, namely with a score of ≥ 75 .

Discussion of the Validity of worksheet based on PBL

According to Nieveen (1999), the credibility of a developed product can be assessed through content validity and construct validity. Content validity criteria consist of 1) completeness, accuracy, and relevance of teaching materials with the subject, curriculum, and learning goals, 2) alignment of teaching materials with the problem-based learning model, and 3) alignment of teaching materials with components of critical thinking skills. In the criteria for alignment of acid-base material with the Merdeka Curriculum, mode 5 falls under a very valid category. This is due to the fact that a front-end analysis was conducted at the planning stage, which included discussions with chemistry teachers regarding learning activities and an examination of the curriculum implemented at the school. The alignment of learning goals with learning outcomes has been rated mode 5 with a very valid category; this suggests that the learning goals set are compatible with learning outcomes in the Merdeka curriculum.

The alignment of facts, concepts, and images received a mode of 4 with a valid category. This means that the facts, concepts, and images presented in the LKPD are suitable. The alignment of the activity formulation with the PBL syntax achieved a mode of 5 with a very valid category. This indicates that the activity formulation listed in the LKPD aligns with the PBL syntax, as outlined by Arends (2008), which includes (1) introducing students to the problems, (2) organizing students in learning, (3) assisting students individually or in groups during investigations, (4) producing and presenting their work results, (5) analyzing and evaluating the problem-solving process. The following is an example of how the worksheet contents will appear based on the PBL syntax.

Fase 1: Orientasi Peserta Didik pada Masalah

Datayya Sakti Wang yang tak kunjung sembuh

Fase 2: Mengorganisasi Peserta Didik untuk Belajar

Berdasarkan masalah, kemukakanlah hipotesis untuk membantu Rika mengetahui penyebab sakit maag yang disebabkan oleh makanan!

Pembahk anda berpikir bagaimana cara mengidentifikasi sifat asam dan basa pada suatu makanan dan minuman? Fatur dan Richa berpikir untuk melakukan percobaan untuk menentukan sifat asam basa terhadap suatu larutan menggunakan indikator asam basa. Mereka menyiapkan larutan sampel yang akan diuji seperti larutan jeruk, cuka, sprite, obat maag, dan gula. Fatur mencari

Fase 3: Membimbing Penyelidikan Kelompok

Ayo Bereksperimen

Sebelum memulai percobaan, cobalah untuk membaca literatur terlebih dahulu mengenai perubahan warna yang terjadi pada tiap indikator yang digunakan. Kemudian tuliskan langkah percobaan!

Alat

- Pelat tetes 1 buah
- Pipet Tetes 7 buah
- Kertas label

Bahan

- Larutan sampel (air jeruk, cuka, sprite, obat maag, larutan gula)
- Indikator alami (kunyit dan kol ungu)

Langkah Percobaan

Fase 4: Mengembangkan dan Menyajikan Hasil Karya serta Memamerkannya

HASIL PENGAMATAN

Tuliskan hasil percobaan pada tabel dibawah ini!

No	Larutan	Warna larutan dengan ekstrak kunyit		Warna larutan dengan ekstrak kol ungu	
		Sebelum	Setelah	Sebelum	Setelah
1	Larutan gula				
2	Jeruk				
3	Cuka				

Fase 5: Menganalisis dan Mengevaluasi Proses Pemecahan Masalah

Bagaimana sifat asam dan basa dapat mempengaruhi kondisi lambung?

Figure 1. Display of PBL syntax

The suitability of the contents of the worksheet with the criteria for improving critical thinking skills refers to the components of critical thinking according to Facione (2015), which consist of 6 components in critical thinking, namely interpretation, analysis, explanation, inference, evaluation, and self-regulation. However, in this research, there are only 4 components, namely interpretation, explanation, analysis, and inference. The interpretation component obtained mode 5 with a very valid category. This means that the contents of the worksheets are in accordance with the criteria for improving the critical thinking interpretation. Sub-interpretation includes categorizing, conveying significance, and classifying meaning (Saxton, 2012). The analysis component obtained a mode of 5 with a very valid category. This means that the contents of the worksheets are in accordance with the criteria for improving critical analytical thinking skills. According to Saxton (2012), aspects of analysis include connecting opinions with problems, analyzing arguments, and detecting arguments. The inference component obtains mode 4 with a valid category. This means that the contents of the worksheet match the criteria for improving inference skills. The activity carried out is to conclude the

results of the experiment. The final component of the explanation also received mode 4 with a valid category. This means that the contents of the worksheet are in accordance with the criteria for improving the explanation. The activities carried out in the sub-analysis provide reasons for the answers given based on experimental results. The following are examples of activities on the worksheet according to critical thinking skills.

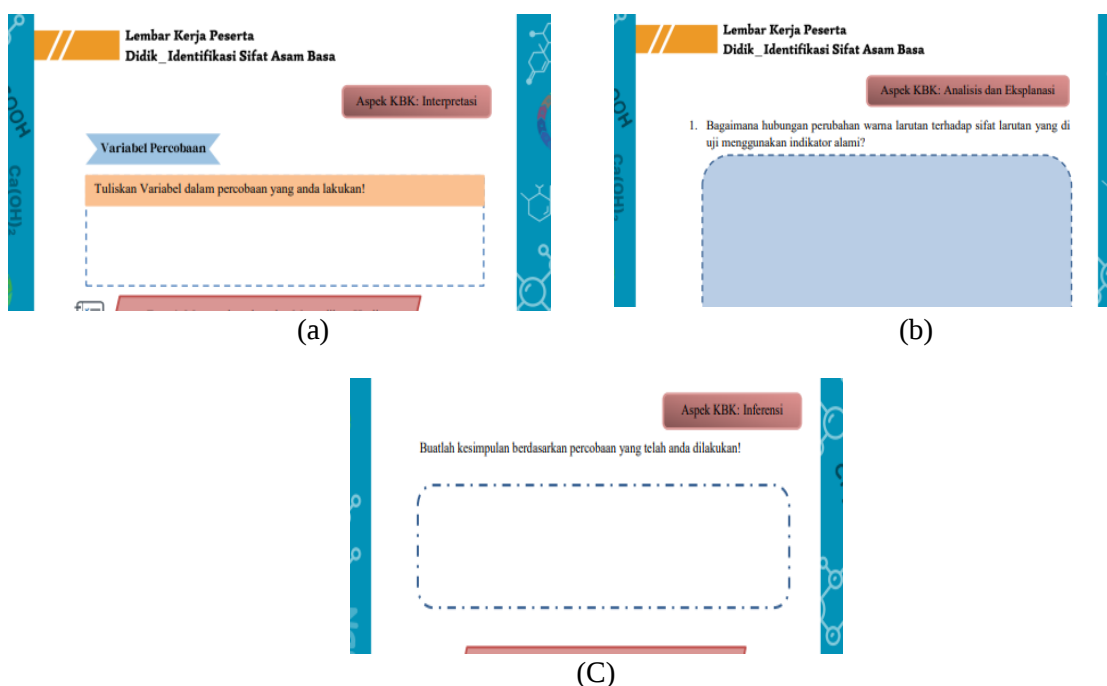


Figure 2. Example of critical thinking component

Based on Table 5, it is known that the content validity of the worksheet developed obtained mode value of 5 with very valid criteria.

Meanwhile, the construct validity includes presentation, language, and graphic criteria. The presentation criteria consist of two aspects of the statement. The first aspect, namely that the worksheet cover presents the contents of the worksheet, obtained a mode value of 5. This is in line with the opinion of Pratama (2014), which states that the cover of a worksheet does not only function as a tool to attract attention but also as a communication tool that provides information related to the contents of the worksheet. The second aspect, namely the worksheet, allows students to actively obtain mode 4 scores. The following is the cover of the worksheet developed.



Figure 3. worksheet cover

The language criteria consist of two aspects: (1) writing worksheets in accordance with PUEBI and (2) writing worksheets using terms that are easy to understand and consistent, each of which gets mode 5 with very valid criteria. The graphic criteria consist of two aspects: (1) an attractive cover and (2) the use of fonts to make it easier for readers. Both of these aspects get mode 4 with valid criteria. The use and selection of an appropriate font type are very important in preparing worksheets so that they can be used comfortably and do not cause confusion for students. For example, the use of capital letters, bold letters, and marking frames in students' questions and answers. This is in accordance with the opinion of Arsyad (2014), who states that letters printed in bold or italics can emphasize keywords or titles so that they can guide and attract attention to important information.

Discussion of the Practically of worksheet based on PBL

1. Student Response Questionnaire

In this questionnaire, several positive questions are given to be answered "Yes" with a score of 1 and several negative questions to be answered "No" with a score of 1. In the questionnaire sheet there are 7 positive statements and 3 negative statements in numbers 3, 4, and 8. These statements can be grouped into three components. First, the content components listed in numbers 1, 3, 6, 7, 8, 9, and 10. At number 1, the worksheet used was arranged systematically, with 15 students responding positively. Worksheets that are arranged systematically can make it easier for students to understand the material. This is in line with research conducted by Diella et al (2019) which states that structured material can make it easier for students to understand the material independently. Number 3, the worksheet instructions are stated clearly, as many as 13 students responded positively. In numbers 6 and 7, namely the learning activities carried out can motivate students and make it easier to learn acids and bases, each of which received positive responses from 14 students. According to Ritonga, et al., (2021), the use of problems in everyday life can attract students' attention when studying so that they are motivated to learn. Number 8 activities in the worksheet make students active, as many as 13 students responded positively. The activities in the worksheet are arranged according to the PBL model according to Arends (2008) which consists of 5 syntax. The PBL model helps students to develop skills in identifying problems and requires students to work together to solve these problems (Hasanah, et al., 2021).

One of the advantages of the PBL model is that it increases the motivation and learning activities of students, develops critical thinking skills and the ability to adapt to new knowledge, makes it easier to master the concepts studied in order to solve real world problems (Sanjaya, 2013). Number 9 practice questions can improve critical thinking skills and number 10 activities in the worksheet train discussion each received positive responses from 15 students. This is consistent with the research by Chairani and Muchlis (2019) which states that after learning using the PBL model, students have good critical thinking skills. The PBL model also encourages collaboration and communication between students. They work together to find the best solution, share ideas, and give each other feedback (Syarqia, et al., 2024)

Second, the graphic component listed in number 2 with 14 students responding positively and number 5 with 15 students responding positively. Third, the language component is in number 4 with 13 students giving positive responses. Based on Table 6. It is known that the average percentage of student response questionnaires as a whole obtained an average percentage score of 95% in the very practical category (Riduwan, 2015).

2. Observation of Student Activity

Observations are carried out during the learning process using observation sheets to observe and record the implementation of learning in class. The observation sheet was filled in by 3 observers. Each observer was assigned the task of observing one group. On this sheet, there are 9 relevant activities and 1 irrelevant activity. Relevant student activities contained in the observation sheet include (1) Students paying attention to the teacher's explanation, (2) Students reading the phenomenon/problem, (3) Students expressing different opinions regarding the phenomenon, (4) Students formulating and conveying the problem formulation based on the phenomenon (5) Students create or design experiments (6) Students write and convey experimental variables (7) Students carry out experiments (8) Students analyze experimental data and (9) Students write conclusions as for irrelevant student activities, namely

talking, joking, playing on cellphones, and so on. Based on Table 7, it can be seen that the percentage of relevant student activities is greater than the percentage of irrelevant student activities and increases with each meeting. This means that student activities can be said to be carried out in accordance with the expected learning plan and strengthen the practicality of the results of the student response questionnaire.

Discussion of the Effectiveness of Worksheet Based on PBL

1. Critical Thinking Skills of Students

This critical thinking skills test consists of two test stages, namely, the pretest and the posttest. The critical thinking components contained in the test are interpretation, explanation, analysis, and inference. The maximum score for each indicator is 10. This test sheet consists of 9 questions, including 2 interpretation questions, 2 explanation questions, 3 analysis questions, and 2 inference questions. So that the maximum score that students will get if they are able to answer correctly according to the scoring is 90. The score will be interpreted into a value of 1-100. Students will take a pretest to determine their initial critical thinking skills. After that, students will carry out learning activities using worksheets based on PBL, which consists of 3 parts. Then, students will take a posttest to determine the improvement in critical thinking skills after applying the worksheet. The activities in the worksheet have been aligned with the critical thinking components to be improved in the acid-base material.

Interpretation, according to Facione (2015), is a skill to understand and express the meaning of various experiences, situations, data, or events. The activities in the worksheet that will be carried out by students on interpreting indicators are posing problems, determining experimental variables, and writing down observation results. In the critical thinking skills worksheet, interpretation is listed in syntax 1 orienting students to the problems, where students are asked to formulate problems based on phenomena. Syntax 3 guides group investigations, where students write down experimental variables, and Syntax 4 develops and presents the results of their work; students are asked to write down observations based on the results obtained into an observation results table.

Explanation is the skill of being able to establish or provide reasons logically (Facione, 2015). In the analytical, critical thinking skills worksheet listed in Syntax 2, organizing students to learn, in this syntax, the sub-activity carried out is writing/creating experimental procedures, and in syntax 4, developing and presenting the results of the work because the sub-activity provides reasons or opinions based on the facts and concepts of acids and bases in the questions provided.

Analysis is the ability to identify goals and connect statements, questions, concepts, and descriptions to reveal reasons, information, and opinions (Facione, 2015). on the worksheet, the analysis component is listed in syntax 4 to develop and present the results of the work, with activities analyzing experimental results and answering questions listed on the worksheet. Then there is syntax 5, which analyzes and evaluates the problem-solving process. One of the differences between the PBL model and other learning models is that it evaluates and provides solutions to the problems presented.

Inference is the skill of identifying evidence and gathering evidence to draw reasonable conclusions, write down guesses, and consider relevant information (Facione, 2015). In the worksheet, the inference component is listed in syntax 4, developing and presenting the results of work, with the activity of drawing conclusions based on experimental results. The following is a recapitulation of the students' pretest and posttest results in each aspect.

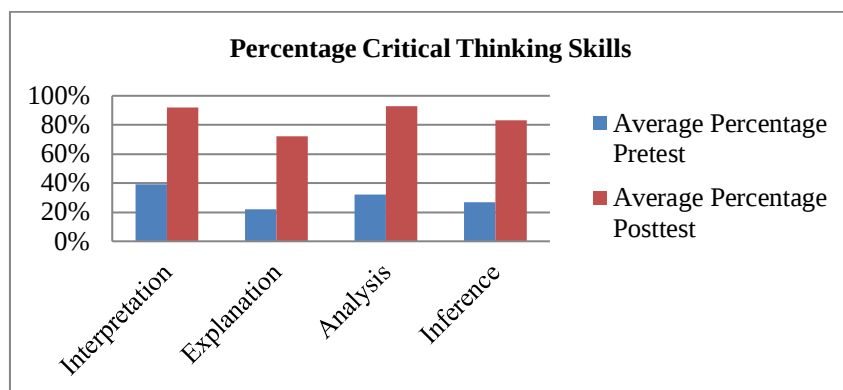


Figure 4. Percentage Diagram of Pretest and Posttest

Based on the picture above, it indicates that the accumulation of the interpretation component gets a pretest percentage of 39% and a posttest percentage of 92%, the explanation component gets a pretest percentage of 22% and a posttest percentage of 72%, the analysis component gets a pretest percentage of 32% and a posttest percentage of 93%, and in the inference component, the pretest percentage was 27%, and the posttest percentage was 83%. Based on this, it can be concluded that students' critical thinking abilities have improved after using worksheets based on PBL, which is strengthened by the N-Gain value for each student who obtained a score > 0.3 with medium and high criteria, as shown in Table 8. in line with research conducted by Ritonga, Areeisty, and Zulkarnaini (2021) that PBL proved significant in improving students' critical thinking skills. This is because students are able to express critical questions so that analytical and critical skills are trained and have an impact on students' skills in solving more complex problems.

2. Knowledge Test

Based on Table 9, it is known that all students have fulfilled individual requirements because each student has achieved a score of ≥ 75 . This knowledge test is used as supporting data for the effectiveness of the worksheet. This test is in the form of multiple choice questions totaling 10 questions and consisting of 6 indicator questions. The following is a recap of the test results for each question item.

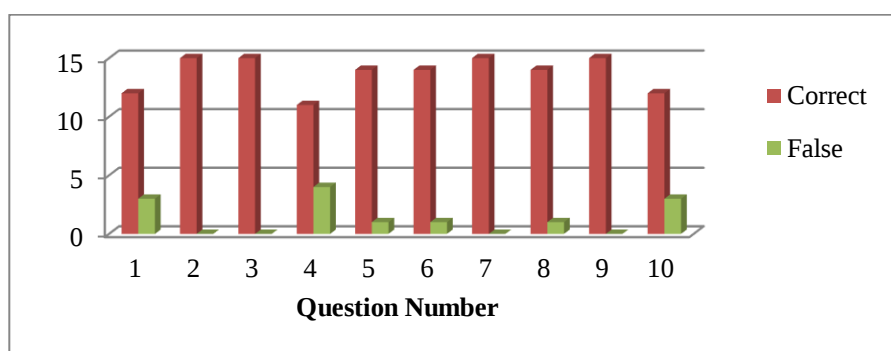


Figure 5. Recapitulation of Student's Answers

Based on Figure 5. it can be seen that many students answered incorrectly on numbers 1, 4, and 3. According to Newman's (1977) procedure, there are 5 error factors that can occur when students answer questions, namely (1) reading error, (2) comprehension error, (3) transform error, (4) weakness in process skill, (5) encoding error. If you look at the students' answers when taking the acid-base knowledge test, it can be seen that one of the factors that causes errors in answering is errors in reading, which can be caused by students not being careful in reading, for example, in question number one there is a distracting word. According to Susanti and Taufik (2019), reading errors can occur because students cannot recognize the words or symbols in the problem, so they cannot solve the problem.

Another factor is errors in transformation or inappropriate approaches to problem-solving. Student errors occur when doing calculations. As in number 4, students forget to convert the pOH value to pH.

Then, in number 10, students have difficulty calculating the pH value. According to Susanti and Taufik (2019), errors in reading may occur because students cannot understand the words and symbols in the questions. Another reason is an error in transformation or an inappropriate approach to solving the problem. An error occurred while performing the calculation. As in number 4, many students forget to convert the pOH value to pH. Then, in number 10, there is difficulty in calculating the pH value. This can happen due to difficulties in basic concepts so that in complex concepts, the errors are greater (Laksono, 2020).

CONCLUSION

Based on the results of the research that has been carried out, it can be concluded that PBL-based worksheets to improve students' critical thinking skills on acid and base materials are suitable for use in terms of validity, practicality, and effectiveness. The worksheet was declared valid in terms of the content validity mode score of 5 in the very valid category and construct validity of 4 in the valid category. The practicality of worksheets is reviewed from the results of the student response questionnaire, namely that students respond positively to the use of worksheet-based on PBL to improve critical thinking skills and is supported by the results of observing that students' relevant activities are greater than irrelevant activities. The effectiveness of the LKPD is reviewed from the results of the critical thinking skills posttest in the aspects of interpretation 92%, explanation 72%, analysis 93%, and inference 83%. Meanwhile, the N-Gain results from the pretest and posttest of critical thinking skills obtained a score of >0.3 with moderate and high categories. This is supported by the results of knowledge tests where all students have achieved individual mastery with a score of ≥ 75 .

This research was developed on acid-base material to improve critical thinking skills, so it is hoped that future research can include other material that has characteristics for practicing critical thinking skills. and is only limited to four components of critical thinking, so it is hoped that future research will cover all components of critical thinking.

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