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Enhancing Student Outcomes in Acid-Base Titration Through Assessment for Learning

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Abstract: The purpose of this study was to describe the implementation of assessment for learning-oriented learning and learning outcomes on acid-base titration material in class XI. This research was conducted in class XI-1 and XI-5 SMA Giki 1 Surabaya. The results showed that the implementation of assessment for learning-oriented learning on acid-base titration material as a whole received very good criteria. This is evidenced by the average percentage of implementation scores at the first meeting of 99.3% and 98.5% for classes XI-1 and XI-5, as well as the second meeting of 99% and 99.5% in classes XI-1 and XI-5 with the criteria for each meeting is very good. Learning outcomes through assessment applications for learning-oriented learning have increased in one sample t-test. The test found that posttest2 XI-5 - posttest2 XI-1 in both classes got a p-score> 0.05, then Ho was accepted, and Ha was rejected. Thus, the score for posttest 2 XI-1 was smaller than that of posttest 2 XI-5. There is no significant difference in posttest 2 between the two classes. So from this, it can be concluded that learning that applies the Assessment for Learning-oriented student worksheet is effective even though the average results of the two classes show differences.

Keywords: Assessment for Learning, Feedback, Acid-Base Titration, Learning Outcomes.

Introduction

Learning is one of the important processes in the educational implementation process between teachers and students. Learning activities can improve students' understanding, creativity, activeness, and power of thinking, and they cannot be separated from the guidance and responsibilities of a teacher [1]. The teacher acts as a facilitator who can direct each material in the teaching and learning process to students. Hence, there needs to be facilities and infrastructure as support through a good learning process can create quality education and optimal learning outcomes. In this case, some things influence learning activities, such as the learning media used by teachers to support learning in class [2].

Preparing quality human resources is a challenge for the development of the Indonesian nation in the 21st century, especially in education. To face the competition of the era of globalization or the 21st century, humans must master four skills known as 4C, including critical thinking and problem-solving, creative thinking, communication, and collaboration [3]. Critical thinking is a way of thinking that is reflective and reasonable and focused on determining what to believe and what to do. Critical thinking skills are important in scientific thinking because they enable students to solve social, scientific, and practical problems effectively based on scientific investigations and intellectual capital, a fundamental part of human maturity [4].

Critical thinking skills can be trained in various subjects in school [5]. One of the basic competencies in chemistry learning. In the chemistry learning process, the learning model plays an important role in helping students understand the material, and learning media is also needed. Learning media plays a very important role in learning because it can help achieve learning goals better and faster [6].

One learning media often used to help students learn is the Student Worksheet, abbreviated as a student worksheet. Student worksheets are teaching material in the form of sheets containing material, summaries, and instructions for carrying out tasks as a guide for students to carry out learning activities [7]. In the learning process, student worksheets encourage students to be actively involved [8]. In addition, student worksheets are also the easiest teaching material to learn and, in conveying concepts, can explain material and questions and apply them in everyday life [9]. Using student worksheets is expected to increase students' activeness in learning to achieve learning objectives [10]. Student worksheets with a problem-based learning approach are needed to improve students' critical thinking skills [11].

Chemistry is a part of Natural Sciences that studies the structure, composition, properties, and changes in matter and the energy that follows these changes [12]. Many materials exist in nature, and each is studied in chemistry. The amount of material in chemistry causes students to have difficulty learning it. Chemistry is generally considered difficult compared to other subjects. Learning chemistry is like learning a new language with abstract concepts [13]. In addition, understanding related chemical concepts cannot be separated because they are interconnected, thus causing students to have difficulty learning in working on the questions given, either in the form of assignments or tests.

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The complexity and abstract nature of chemical concepts, such as those found in acid-base titration materials, often become obstacles in the learning process [14]. An acid-base titration is a topic in the chemistry curriculum because it involves understanding chemical reactions, selecting indicators, and analyzing experimental data. There are three types of titration curves, depending on the titration reaction performed, such as titration of strong acids with strong bases, weak acids with strong bases, or strong acids with weak bases [15]. The three types of titration curves produce different graphical shapes because when an acidic solution is added to a basic solution, its pH increases, and vice versa; when a basic solution is mixed into an acidic solution, the pH of the solution will decrease. Many learners have difficulty understanding these concepts and applying them in practice.

Assessment for Learning is an approach that emphasizes using formative assessment to provide constructive feedback and direct learners in their learning process. This approach has great potential for improving learners' learning outcomes [16]. Using these professional judgments and turning them into feedback regarding the quality of individual work is the focus of Assessment for Learning. Successful Assessment for Learning strategies results in continuous improvement in learner progress. A key feature of Assessment for Learning is the effective feedback teachers provide learners about their progress [17]. In the research conducted by Safithri and Muchlis (2022), the test results before conducting the learning assessment (pretest) showed that the pretest had 2 students who were complete and the remaining 34 students were not complete, giving a classical completeness rate of 5.56%. The posttest of the learning implementation assessment showed that 36 students achieved a classical completion rate of 100%, so the learning was implemented optimally [19].

The learning outcomes of grade XI high school students through applying performance assessments in acid-base titration practicums increased students' activity and learning outcomes. In cycle 1, the activity was 51.5%, and student learning outcomes were 61%. In the second cycle, the activity was 72.5% (moderate category), and student learning outcomes were 69% (moderate category). In the third cycle, teacher activity was 85% (good category), and student learning outcomes were 85% (high category). [20].

This study aims to improve student learning outcomes in Acid Base Titration through Learning Assessment in Grade XI. The urgency in this study is that developing critical thinking skills will enable individuals to develop more reasonable arguments for assignments, projects, and questions during exams and everyday life. Individuals can use evidence to justify their arguments and ideas.

Research Methods

Place and Time of Research

The place of this research is SMA GIKI 1 Surabaya class XI. This research was conducted in the May 2024 odd semester of the 2023/2024 school year adjusted to the material of acid-base titration sub-material of titration of strong and strong bases and weak and strong bases.

Research Design

This quantitative descriptive research systematically, factually, and accurately describes the results of students' performance during the implementation of Assessment for Learning. The research conducted is a pre-experiment research. Pre-experiment research is conducted on one group only, without other groups to compare [21]. The research design used in this study is a group Pretest Posttest Design, which is research conducted in one group only without a comparison group described as follows:

Description:

O1	X	O_2

O_1 = Learning outcomes before applying assessment for learning
X = Application of assessment for learning
O_2 = Learning outcomes after applying assessment for learning

Data Analysis

Analyze the implementation of learning carried out by the teacher by calculating the percentage of steps in the Assessment for Learning phase that are implemented using the following formula: [22]

$$\%implementation\ of\ learning = \frac{\sum score\ obtained}{\sum maximum\ score} \times 100\%$$

The average results of the quality of the implementation obtained are then converted as listed in Table 1 below. [23].

Table 1. Learning Implementation Criteria

Percentage (%)	Description
0 – 20	Not very good
21 – 40	Not good
41 – 60	Fairly good
61 – 80	Good
81 – 100	Very Good

Assessment for Learning-oriented learning can be said to have been well implemented if the learning implementation criteria reached 61% (good or very good).

Data processing was done with the help of SPSS software and Minitab 18. The normality test used the Shapiro-Wilk test on SPSS for the prerequisite test. For hypothesis testing, use one sample t-test on Minitab 18.

Results and Discussion

Learning Implementation

The implementation of assessment for learning-oriented learning in this study was observed by three observers of Unesa Chemistry Education students. The filling of the observation sheet is adjusted to the rubric of learning activities carried out by the teacher. The scores obtained from 3 observers were then averaged and

converted into the score of learning implementation. The results of the observation of the implementation of assessment for learning-oriented learning activities are shown in Figure 1.

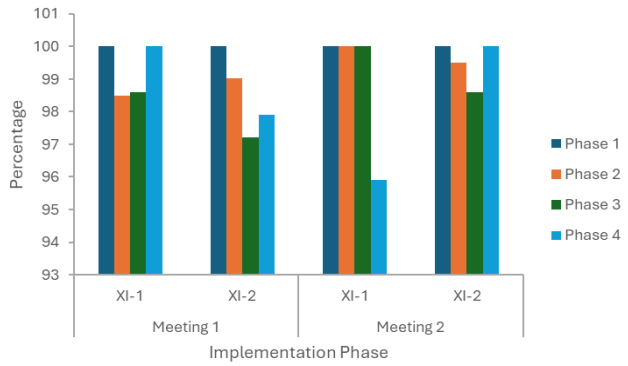

Figure 1. Learning Implementation Chart of XI-1 and XI-5 class

This study uses the steps according to Rahayu (2022). Still, the third and fourth steps are combined because Assessment for Learning is characterized by feedback, so there is information on activating and providing feedback. In addition, the feedback cannot stand alone, so combining it with the third step is appropriate based on the above steps. In the first step, the teacher must clearly explain what students must achieve in the learning process and the criteria for assessing students' success. In the second step, the teacher should be able to create a classroom environment conducive to productive discussions and design tasks that allow learners to demonstrate their understanding of the material learned. The conducive classroom environment involves creating a space that supports positive interactions, motivates active participation from all learners, and encourages critical thinking. In the fourth step, teachers motivate learners to take responsibility for their learning, including setting personal goals and identifying effective learning strategies [24].

Based on the description above, the steps in the Assessment for Learning-oriented learning can be written in 4 parts, including (1) Clarifying learning objectives and learning success criteria, where in this phase, the average obtained in both meetings in classes XI-1 and XI-5 was 100%. (2) Engineering effective class discussions and other learning tasks that provide evidence of learner understanding, with an average of the first meeting of classes XI-1 and XI-5 of 98.5% and 99.02% and the second meeting of classes XI-1 and XI-5 of 100% and 99.5%. (3) Activating students as a source of learning for each other and providing feedback that moves students towards better, with the average acquisition of the first meeting of classes XI-1 and XI-5 of 98.6% and 97.2% and the second meeting of classes XI-1 and XI-5 of 100% and 98.6%. (4) Activating learners as owners of their own learning, with an average of the first meeting of classes XI-1 and XI-5 of 100% and 97.9% and the second meeting of classes XI-1 and XI-5 of 95.9% and 100%.

Figure 1 shows that assessment for learning-oriented learning has been implemented and received an average of very good ratings in each phase in all meetings in classes XI-5 and XI-1. This means that the teacher can condition the learning according to the teaching module that has been made. The percentage of agreement between observers in observing the quality of learning implementation is calculated by the total score obtained by each observer divided by the maximum score and multiplied by 100%. The average results of the quality of implementation obtained are then converted. Assessment for learning-oriented learning can be declared well implemented if the learning implementation criteria obtained reach 61% (good or very good criteria). Based on the calculation data, the agreement between observers of learning implementation shows generally very good results, with the smallest percentage of 95.9% and the largest is 100%. After learning in each class for two meetings, students are given a critical thinking skills posttest at each meeting to determine the magnitude of the increase in students' critical thinking skills.

Learning Outcomes

Measuring learning outcomes using pretest instruments given before the application of assessment for learning-oriented learning, posttest one given after the application of assessment for learning-oriented learning in the first meeting, and posttest two given after the application of assessment for learning-oriented learning in the second meeting. The results of the pretest, posttest 1, and posttest two scores of students in both classes, XI-1 and XI-5, can be seen in Table 2 below.

Table 2. Data on Student Pretest and Posttest Results

No.	Pretest Score		Posttest Score 1		Posttest Score 2	
	XI-1	XI-5	XI-1	XI-5	XI-1	XI-5
1	40	40	100	80	100	80
2	20	40	80	60	80	100
3	40	60	80	80	100	80
4	60	20	80	60	80	80
5	20	20	80	80	100	80
6	40	40	60	60	80	80
7	40	40	60	80	80	100
8	60	80	80	80	100	100
9	40	60	80	60	100	80
10	60	40	100	80	100	80
11	40	60	80	80	100	80
12	20	60	80	60	100	80
13	40	40	80	60	80	100
14	40	60	100	80	100	100
15	80	20	60	60	80	100
16	80	60	80	80	80	60
17	40	40	60	80	80	80
18	40	60	80	60	80	100
19	60	40	80	60	100	60
20	40	60	80	80	100	100
21	40	20	80	80	80	80
22	80	20	80	100	80	100
23	80	60	60	100	80	100

24	60	20	80	40	100	60
25	20	60	80	80	80	100
26	60	60	80	100	80	100
27	40	60	60	80	100	80
28	40	40	80	80	80	80
29	40	20	80	80	80	80
30	40	40	80	60	80	100
31	40	20	80	80	100	80
32	60	20	80	100	80	100
33	40	20	60	80	80	100
34	40	60	60	60	80	100
35	60	40	60	100	80	100

The pretest, posttest 1, and posttest 2 scores were used to measure the improvement of critical thinking skills using the paired sample t-test, with analysis requirements in the form of data normality tests [25]. The SPSS-assisted normality test used the Shapiro-Wilk test and obtained normally distributed data with $\alpha \geq 0.05$ [26]. The Shapiro-Wilk test was used because the data in this study amounted to less than 50 students. The Shapiro-Wilk test is usually used on samples of less than 50 to produce accurate decisions. Data on the results of pretest and posttest normality testing in both classes using SPSS are presented in Table 3.

Table 3. Normal Test Results of Class XI-1 and XI-5

XI-1				X1-5		
	Shapiro-Wilk			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.963	35	.278	.950	35	.113
Posttest 1	.951	35	.117	.949	35	.107
Postest 2	.953	35	.136	.952	35	.133

The pretest, posttest 1, and posttest 2 values for class XI-1 are normally distributed, with the pretest results getting a significance of 0.278 > 0.05, posttest 1 getting a significance of 0.117 > 0.05, and posttest 2 with a significance of 0.136 > 0.05. Then, in class XI-5, the pretest, posttest 1, and posttest 2 values were normally distributed, with the pretest results having a significance of 0.113 > 0.05; posttest 1 had a significance of 0.107 > 0.05; and posttest 2 had a significance of 0.133 > 0.05. This shows that Ho is rejected and Ha is accepted, meaning that the data is normally distributed based on the decision-making hypothesis.

Data is normally distributed if the significance score> 0.05 (sig. > 0.05) [27]. Following the results obtained in both classes, the significance value is > 0.05. Based on the normality test that has been carried out, the parametric test that can be done is the one-sample t-test. The one-sided t-test is used to evaluate the improvement of students' critical thinking skills by comparing the posttest and average pretest scores.

Table 4. Average of Pretest, Posttest 1, and Posttest 2 of class XI-1

Descriptive Statistics					
				95 % Lower Bound	
Sample	N	Mean	StDev	SE Mean	For μ
Pretest	35	45.49	7.67	1.30	43.29
Posttst 1	35	75.60	6.87	1.16	73.64
Posttest 2	35	86.14	6.73	1.14	84.22

Table 5. Average of Pretest, Posttest 1, and Posttest 2 of class XI-5

Descriptive Statistics					
				95 % Lower Bound	
Sample	N	Mean	StDev	SE Mean	For μ
Pretest	35	47.37	10.13	1.71	44.42
Posttst 1	35	75.89	6.58	4.11	74.01
Posttest 2	35	85.40	6.04	1.02	83.67

Based on Table 4 and Table 5, the average of both classes in each assessment has increased, especially in pretest and posttest 1, where class XI-5 is above class XI-1. However, when posttest two was conducted, it showed that the average results of class XI-5 were below class XI-1 with results of 85.40 and 86.14, with a difference of 0.74. From this, a different test was carried out for posttest two between the two classes with a parametric test, namely the right party t-test. Right-party hypothesis testing is hypothesis testing where the null hypothesis (Ho) reads "smaller is equal to" and the alternative hypothesis (Ha) reads "greater" with the hypothesis proposed as follows:

Ho = $\mu 1 \leq \mu 2$, XI-1's posttest 2 score is smaller or equal to XI-5's posttest 2 score.
Ha = $\mu 1 > \mu 2$, XI-1's posttest 2 score is greater than XI-5's posttest 2 score.

The determination of the hypothesis conclusion is as follows:

a) If the p-score > 0.050, Ho is accepted and Ha is rejected; thus, the posttest 2 score of XI-1 is smaller than the posttest 2 score of XI-5. There is no significant difference in posttest 2 between the two classes.
b) If the p-score <0.050, Ho is rejected, and Ha is accepted. Thus, the posttest 2 score of XI-1 is greater than the posttest 2 score of XI-5. That is, there is a significant difference in posttest 2 between the two classes.

Figure 6. T-test results Posttest 2 XI-1 - Posttest 2 XI-5

Test	
Null Hypothesis	$H_{01}\mu$_difference = 0
Alternative Hypothesis	$H_{12}\mu$_difference = 0
T-Value P-Value	
-0.46 0.677	

Acids and bases are important concepts in chemistry that help understand chemical reactions and determine the properties of a substance. Acids and bases are one of the studies in the chemistry material for grade XI IPA SMA/MA, even in the semester. This topic is important to understand because it is applicable and widely used to study scientific studies in other fields. Acid-base material is a prerequisite for mastering the next material: buffers, salt hydrolysis, and acid-base titration [28]. Acid-base material is very complex, as evidenced by the fact that acid-base

material meets every level of macroscopic, submicroscopic, and symbolic representation. Therefore, if students cannot understand the acid-base material completely, its application will be fatal. Difficulty in understanding the topic of acids and bases can be caused by students' inability to make the transition of understanding between macroscopic, microscopic, and symbolic representations, which has the potential to cause students' understanding to be inaccurate and even tend to cause misconceptions [29].

Student worksheets based on discovery learning on Acid-Base material were very good in terms of the suitability of content and construction as well as readability, so the worksheet developed was suitable for use in the chemistry learning process [30]. In addition, the student worksheet based on discovery learning used student worksheet based on discovery learning on Hooke's law material was effective in improving students' critical thinking skills [31]. The effectiveness analysis based on the N-gain score showed that the student worksheet was categorized as effective [31]. Based on the study results, it can be concluded that the student worksheet developed meets the criteria of valid, practical, and effective so that it is suitable for use as a learning medium to improve the critical thinking skills of elementary school students in science learning.

Conclusion

Implementing the assessment for learning-oriented worksheet application to improve students' critical thinking skills on acid-base titration material as a whole received very good criteria. This is evidenced by the average percentage of implementation scores at the first meeting of 99.3% and 98.5% for classes XI-1 and XI-5, as well as the second meeting of 99% and 99.5% in classes XI-1 and XI-5 with the criteria for each meeting very good. Learning outcomes through assessment applications for learning-oriented learning have increased in one sample t-test. In the test, it was found that for posttest 2 of class XI-5 - posttest 2 of class XI-1 got a p-score > 0.05, Ho was accepted, and Ha was rejected. Thus, the posttest 2 score of XI-1 was smaller than the posttest 2 score of XI-5. There is no significant difference in posttest 2 between the two classes. From this, it can be concluded that learning that applies the Assessment for Learning-oriented worksheet is effective even though the average results of the two classes show differences in the posttest 2 between the two classes.

Author's Contribution

Klara Dinda Ayu Ningtryas: Designing the research, collecting and analyzing data, writing the main draft, and correspondence with the journal. Muchlis: Supporting the research process and providing input on writing journal articles. Ilham Pradana Putra Harahap: Assisting in collecting research data and providing certain technical facilities needed in the research

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