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Development of Worksheet Based on Assessment for Learning (AfL) to Improve Problem Solving Skills on Acid-Base Material

Merynke Ayu Nava Tiana & Muchlis*
Department of Chemistry Education, Faculty of Mathematics and Natural Science, State University of Surabaya, Jl. Ketintang, Ketintang, Kec. Gayungan, Indonesia 60231
* Corresponding Author e-mail: muchlis@unesa.ac.id

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Abstract
The purpose of this study is to ascertain how well Assessment for Learning (AfL)-based learner worksheets enhance students' ability to solve problems involving acid and base materials, particularly salt hydrolysis sub-materials. This study is a development study that is restricted to the develop stage and uses a 4D model. The research subjects were XII grade students at SMAN 14 Surabaya. The research instruments consisted of validation sheets, pre-test, and post-test of problem solving skills. Validation was conducted by 3 expert validators with the results showing that the worksheet met the valid criteria in terms of content, construct, and graphics. Limited trials were conducted in two meetings using two worksheets. The results of the Wilcoxon test revealed a significant difference between the pre-test and post-test, with a significance value of 0.000 ($p < 0.05$). According to the N-Gain analysis, there were five pupils in the low group, eleven in the medium category, and fourteen in the high category. According to these findings, students' problem-solving abilities are effectively enhanced by the AfL-based worksheets. Through a contextual approach and group discussions, this worksheet effectively combines Polya's problem solving paradigm with the stages of AfL

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INTRODUCTION

Learning outcomes are part of the core curriculum that outlines essential subjects students need to master. These outcomes serve as a guide in planning and evaluating learning, with a focus on assessing students' academic achievement (Aulia et al., 2023). By the end of Phase F, students are expected to apply acid-base concepts in daily life and understand organic chemistry (Kemendikbudristek, 2022). One of the key topics in acid-base material is salt hydrolysis, which extends the acid-base topic by explaining reactions that result in water as a byproduct (Fitriza et al., 2021).

A study by Lestari et al. (2021) found that developing supplementary teaching materials effectively improved students' problem-solving skills on the topic of salt hydrolysis, shown by a classical mastery rate of 77.78%—exceeding the minimum threshold of 75%. Previously, low mastery was linked to students' difficulty understanding this complex topic, which requires a sequence of prior concepts such as acid-base theory, reaction equations, equilibrium, molarity, limiting reactants, and pH calculations (Gesmawati & Fitriza, 2023).

Nusi et al. (2021) noted that students struggled with connecting definitions of acids and bases, identifying them, calculating pH, and writing salt hydrolysis reactions. Similarly, Salmar & Lastisma (2022) reported that students often confused salt hydrolysis with buffer solution concepts, resulting in poor learning outcomes.

These issues underline the need to enhance students' problem-solving abilities. According to Polya (1973), problem-solving is a high-level intellectual activity involving four stages: 1) understanding the problem, 2) devising a plan, 3) carrying out the plan, and 4) reviewing the solution. Given the difficulty of acid-base topics, learning processes must be evaluated to help teachers and students understand their effectiveness. Evaluation is conducted through formative and summative assessments, as stated in Permendikbudristek No. 21 of 2022 on Education Assessment Standards.

Assessment helps determine whether educational goals are being achieved and guides the next steps in teaching. One effective approach is Assessment for Learning (AfL), a continuous assessment method aimed at identifying student progress and providing feedback to improve learning (Rosana et al., 2020; Dini & Muchlis, 2022). AfL involves five key steps: 1) clarifying learning objectives and success criteria, 2) designing effective class discussions and learning tasks that provide evidence of student understanding, 3) giving feedback to support student improvement, 4) enabling students to be learning resources for each other, and 5) encouraging students to take ownership of their learning.

Dini & Muchlis (2022) reported a 90.1% mastery rate after applying AfL, with 90.12% of students responding positively to the experience. This proves that AfL is effective in improving student learning outcomes. AfL also supports students' problem-solving skills by providing feedback, promoting reflection, and adapting instruction to individual needs.

Effective teaching also depends on the use of appropriate learning tools, such as Student Worksheets (LKPD). LKPDs are task sheets that guide students through learning activities individually or in groups, promoting active learning (Sarita & Kurniawati, 2020). Research by Sudarsono & Muchlis (2023) showed that AfL-based LKPDs were valid for improving learning outcomes in buffer solution topics, with an average validity score of 84.5%. The N-gain value increased by 100% (high category), and students gave highly positive responses (88.9%–100%).

Preliminary research at SMAN 14 Surabaya revealed that 94.4% of students found salt hydrolysis difficult, and 80.6% said chemistry lessons still relied on lectures. Furthermore, the implementation of Assessment for Learning and Polya's problem-solving stages had not been fully applied. In AfL: stage 1 was 100% unimplemented, stage 2 was 80.6% unimplemented, stage 3 was 88.9% unimplemented, and stage 4 was 94.4% unimplemented. For Polya's stages: stage 1 was 91.7% unimplemented, stages 2 and 3 were 77.8%, and stage 4 was 88.9%.

Based on this analysis, there is a clear need to develop LKPDs based on Assessment for Learning as a solution to improve students' problem-solving skills, especially in acid-base topics like salt hydrolysis. The proposed title of the research is "Development of Student Worksheets Based on Assessment for Learning (AfL) to Improve Problem-Solving Skills in Acid-Base Materials."

METHOD

The design used in this study is guided by the steps of research and development (Research and Development) by Thiagarajan et al., (1974). In this R&D method, a 4D model is used which is limited only to the develop stage. The stages used are the define stage, the design stage, and the develop stage. A clearer description of the research and development design is described in Figure 1.

The trial was conducted using One Group Pretest Posttest Design. The development trial design is described as follows.

O1 X O2

One Group Pretest Posttest Design

Description:
O1: pretest score (before the implementation of AfL-based LKPD)
O2: posttest score (after the implementation of AfL-based LKPD)
X: LKPD is given to students to improve their problem-solving skills based on Assessment for Learning on acid-base material.

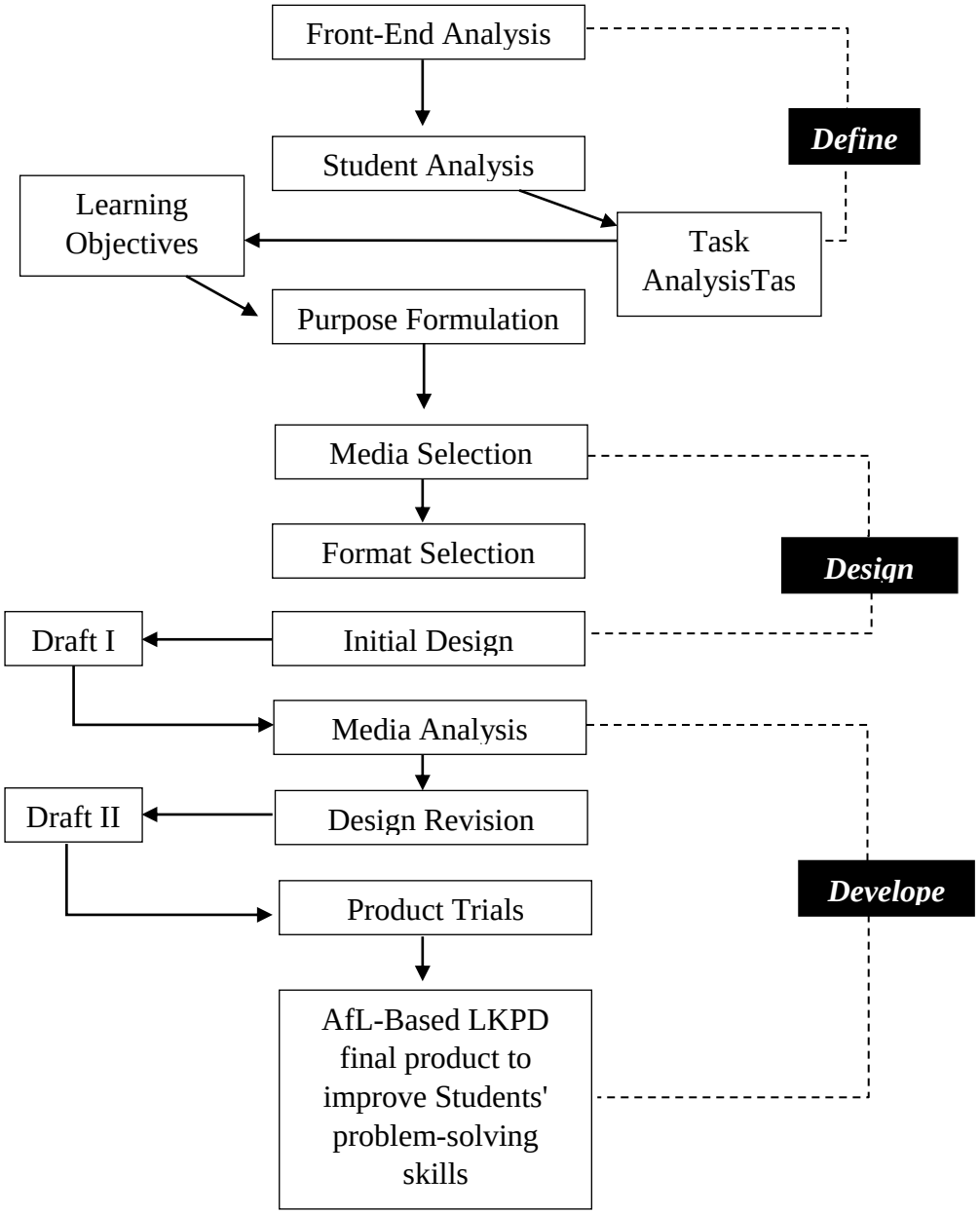

Figure 1. Design Chart 4D Development Stages Up to Develop Stage

This analysis was conducted with the aim of determining the feasibility of LKPD which includes content validity and construct validity. The validation data was filled in by 3 validators. This analysis was conducted based on the criteria listed on the validation sheet. The validator provided an assessment of each component of the criteria based on the Likert scale score as shown in Table 1.

Validation result data is in the form of ordinal data that can be analyzed by determining the mode for each aspect or indicator with the following conditions (Lutfi, 2021) :
a. If the aspect assessed by the validator has a mode score ≥ 4, then the aspect is declared valid.

b. If the aspect assessed by the validator has a mode score <4, then the aspect is declared invalid.

Table 1. Likert Scale Validation Sheet

Scale	Criteria
5	Very Good
4	Good
3	Quite Good
2	Not Good
1	Very Bad

(Riduwan, 2016)

The data from the students' responses were analyzed descriptively quantitatively. In the questionnaire, the students' responses were in the form of positive and negative statements. Scoring was done based on the Guttman scale score as table 2 beloow:

Table 2. Guttman Scale for Learner Response Questionnaire

Answer	Positive Answer Score	Negative Answer Score
Yes	1	0
No	0	1

The data obtained will be analyzed using the following formula:

$$\text{Total Score} = \frac{\text{sum of result "Yes" and "No"}}{\text{Sum of student}} \times 100\%$$

Description:

I. Positive response: If the percentage of response statements is positive, then the positive percentage is obtained from students answering "Yes".
II. Negative response: If the percentage of response statements is negative, then the positive percentage is obtained from students answering "No".

The results of the response questionnaire will be used to determine the practicality of LKPD as a learning element in the acid and base material by using the score interpretation shown in Table 3.

Table 3. Category of Worksheet Practicality

Range	Category
0-20%	Very impratical
21-40%	Less practical
41-60%	Practical enough
61-80%	Practical
81-100%	Very Practical

(Riduwan, 2016)

The improvement of students' problem-solving abilities was then analyzed using the N-gain value. This calculation aims to determine how far the difference in pretest and posttest values is after learning using AfL-based LKPD to improve problem-solving abilities. The calculation of the N-gain value can use the following formula:

$$G = \frac{\text{pretest score} - \text{posttest score}}{(\text{maximum score} - \text{pretest score})}$$

The N-gain value results obtained are interpreted according to the criteria as describe in Table 4.

Table 4. Gain Level Criteria

G	Category
$(g) \geq 0,7$	High
$0,7 > (g) \geq 0,3$	Medium
$(g) < 0,3$	Low

Problem solving skills are said to have been successfully improved if the posttest score is higher than the pretest score and the N-gain value is $0.7 > (g) \geq 0.3$ which is in the moderate criteria.

RESULTS AND DISCUSSION

Thiagarajan's 4D development paradigm, which includes the phases of Define, Design, Develop, and Disseminate, was used to create this study on a worksheet to enhance problem-solving abilities. Only the develop stage is included in this study, and each step is described below:

Define

The first step taken in this study was the observation of chemistry learning at SMAN 14 At the Define stage in this study, a needs analysis was conducted to determine the abilities or competencies that need to be developed by students to improve their learning performance. The front-end analysis's findings demonstrated that SMAN 14 Surabaya's chemistry instruction continues to be teacher-centered, which affects the students' poor problem-solving skills. Only 51% of students can complete problem-solving tasks, according to pre-research findings, placing them in the very poor category. Actually, the school's implementation of the Merdeka Curriculum calls for a student-centered approach in which learners are expected to take an active role in their education. Furthermore, the worksheet continues to emphasize problem-solving without encouraging pupils to comprehend phenomena or hone their critical thinking abilities.

According to an analysis of the students, they prefer learning that involves peer interaction and find traditional teaching techniques boring. This is consistent with the learning theory of Vygotsky and John Dewey, which highlights the value of contextual and cooperative learning in developing problem-solving abilities. In order to comprehend acid and base contents, students indicated a need for more active and collaborative learning, according to the need questionnaire answers. As a result, the learning materials created must be tailored to the individual needs of the students and take into account their desire for contextualized and meaningful learning.

In the task analysis, the development of worksheet is designed to facilitate tasks that train problem solving skills based on the stages of Assessment for Learning (AfL). These tasks include identifying learning objectives, analyzing phenomena, planning problem solving, and conducting self- and peer evaluations. These stages are linked to Polya's problem-solving steps to ensure that learning does not only assess the end result, but also provides a reflective learning process.

Furthermore, the analysis of learning objectives is carried out to ensure that the worksheet developed is able to improve students' problems solving skills, especially in understanding the concept of salt hydrolysis and applying it in the context of everyday life. Learning objectives are formulated specifically in the form of abilities that students are expected to achieve, so the following learning objectives are formulated.

1) Given a phenomenon related to salt hydrolysis in daily life, learners can rewrite the results of their understanding of the nature of salt hydrolysis appropriately based on the phenomenon provided.
2) Given a phenomenon related to salt hydrolysis in daily life, learners can solve problems related to salt hydrolysis reactions using correct scientific reasoning.
3) Provided with several types of salt solutions, learners can write the results of problem solving from the phenomena and activities carried out by salt hydrolysis based on changes in the color of litmus paper indicators correctly and can carry out practical planning properly.
4) Presented with data and arguments, students can solve problems related to the results of salt hydrolysis practicum by analyzing experimental data and providing appropriate scientific explanations appropriately.

Thus, the developed AfL worksheet is expected to be an effective learning media to build students' problem solving skills on acid and base materials in accordance with the demands of the Merdeka Curriculum.

The developed LKPD contains tasks to train students' problem-solving skills that are adjusted to the AfL stage. The tasks given include identifying learning targets, analyzing phenomena, identifying problems related to phenomena, analyzing problem solving in phenomena, conducting peer evaluations, and conducting evaluations of learning outcomes. The relationship between AfL stages, student tasks, and characteristics of problem-solving skills can be seen in the following table 5:

Table 5. The Relationship between Assessment for Learning Stages, Student Tasks in LKPD, and Characteristics of Problem Solving Abilities

Stages *Assessment for Learning*	**Duties of Students in Worksheet**	**Characteristics of Problem-Solving Abilities**
Clarify learning objectives and learning success criteria	Students identify the minimum score target that they want to achieve in learning.	-
Engineering effective class discussions and other learning tasks that provide evidence of participant understanding	Students write down the information obtained on the given phenomenon.	Understanding the problem
	Students identify questions in the LKPD that are related to the problems in them.	Plan troubleshooting
	Students conduct analysis related to the problems given and the experiments that have been carried out.	Resolve issues as planned
Activating learners as a learning resource for each other and providing feedback that moves learners	Students evaluate the results of peer-to-peer answers in the form of conclusions made in groups.	Re-check the results obtained

Stages *Assessment for Learning*	Duties of Students in Worksheet	Characteristics of Problem-Solving Abilities
in a better direction.		
Activating learners as owners of their own learning.	Students evaluate their own learning outcomes during the learning process based on phase 1 of the AfL that they have written.	-

Design

In this stage, the LKPD design is designed by adjusting the established format to be able to improve the ability to solve problems based on AfL and adjust the components in solving problems on the acid and base material, sub-material of salt hydrolysis. The LKPD design that will be developed later contains an initial cover, foreword, introduction, concept map, important information, learning activities, and a list of references to produce a draft that is explained in the table below:

Figure 2. Worksheet Cover Design

The front cover contains the title of the LKPD, namely "Student Worksheet on Acid and Base Hydrolysis of Salt Material Based on Assessment for Learning to Improve Problem Solving Skills", the Merdeka curriculum logo, the SMA logo, and the Unesa logo, supporting images related to the material to be studied in the LKPD, and the student identity box.

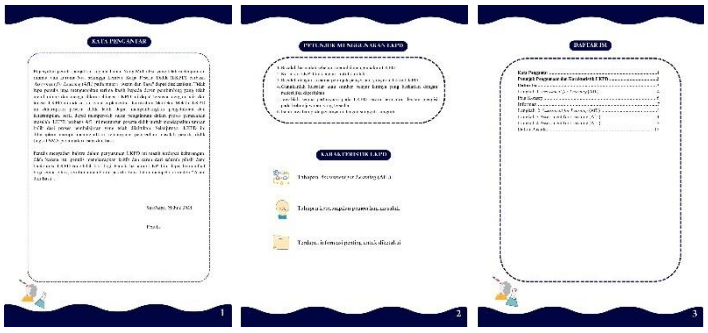

Figure 3. Foreword, Instructions for Use, and Table of Contents

The foreword contains thanks for the smooth preparation of the LKPD and the author's hopes. Instructions for use and characteristics of LKPD which contain how to use LKPD so that students work on LKPD according to the steps in sequence and the characteristics of LKPD which contain the distinctive features of LKPD compared to other LKPD. Table of contents containing details of sub-chapters to make it easier to search for pages in the LKPD.

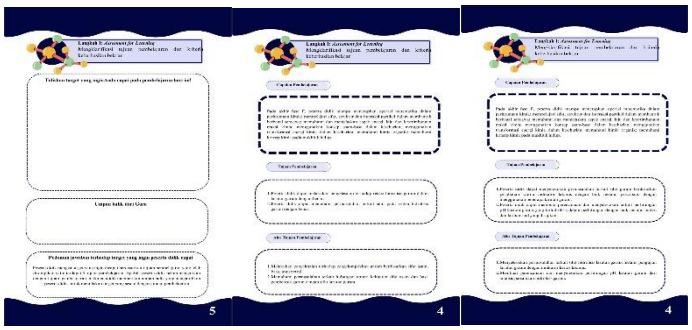

Figure 4. AfL Phase 1 Assignment

Step 1 AfL (Clarifying learning objectives and learning success criteria) contains learning achievements, learning objectives, and learning objective flow so that students know the learning objectives that will be achieved in this learning. The target value column contains learning objectives and the student column to write the target value they want to achieve and the teacher feedback column.

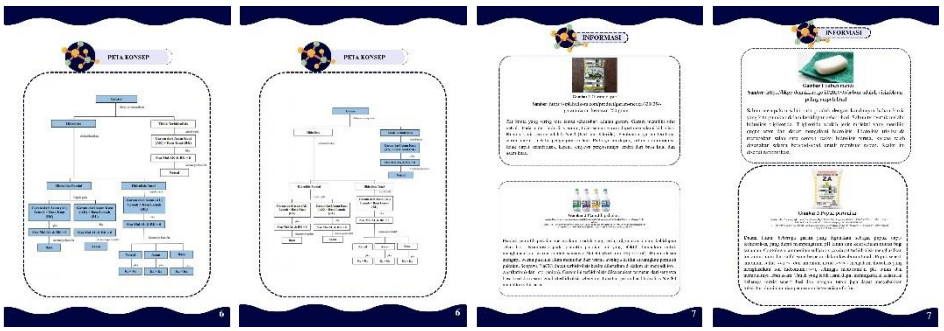

Figure 5. Concept Maps and Important Information

The concept map shows the material to be studied at the meeting. Important information containing information about the function of salt hydrolysis in everyday life in order to expand the knowledge possessed by students.

Figure 6. AfL Phase 2 Assignment

Step 2 AfL (conducting engineering related to effective classroom discussions and assignments in other learning that provide evidence related to student understanding) contains material (1st meeting) and practical instructions (2nd meeting). The section on understanding the problem contains practice questions related to the initial material in the LKPD, then the section on planning problem solving contains practice questions in the form of basic things that students must know at the meeting and a feedback column from the teacher. The section on solving problems according to plan contains practice questions related to learning outcomes or activities that have been carried out by students and a feedback column from the teacher.

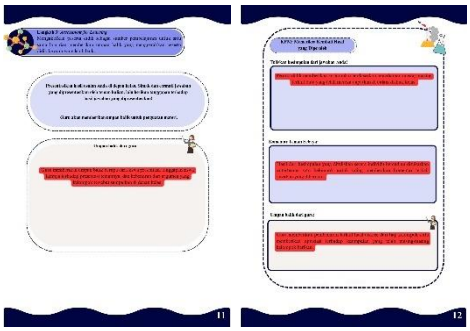

Figure 7. AfL Phase 3 Assignment

Step 3 AfL (activating students to become a source of learning for other students and providing feedback that can move students to become better) contains instructions for presenting the results of LKPD work and a comment column in the form of feedback from the teacher. The section for re-checking the results obtained contains conclusions obtained by students from the results of the work and presentation, a comment column between peers, and a feedback column from the teacher.

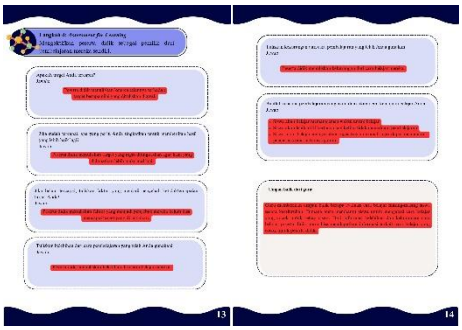

Figure 8. AfL Phase 4 Assignment

Step 4 AfL (activating students as owners of the learning itself) contains questions that refer to learning development, strengths and weaknesses, and the learning methods of each student.

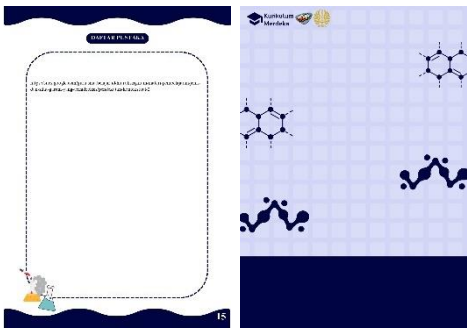

Figure 9. Bibliography and Worksheet Back Cover

The Bibliography contains sources used to create materials in LKPD. The back cover contains the Merdeka curriculum logo, SMA logo, and Unesa logo.

Development

The purpose of the development stage is to produce a final draft of useful media. At this development stage, product validation and limited trials are conducted to obtain data on the feasibility of the worksheet.

Validity

The validation stage is carried out when the worksheet has been improved by adjusting a suggestion and input obtained from the thesis supervisor during the review stage. In terms of content validity, it shows that the contents of the worksheet that have been developed have been adjusted to the learning objectives, stages of Assessment for Learning (AfL), aspects of problem-solving abilities, and acid and base material in the sub-chapter of salt hydrolysis. Meanwhile, construct validity shows that the design of the worksheet that has been developed is interesting to use, the language used in the worksheet is communicative and adjusts according to the rules of good and correct Indonesian. The validation results will later be used to determine the feasibility of the worksheet developed along with other supporting instruments before being tested on students.

Table 6 Worksheet Validity Results

Validity Aspect	Mode		Criteria
	Worksheet 1	Worksheet 2	
Content eligibility	4	4	Valid
Presentation	4	4	Valid
Language	4	4	Valid
Design	4	4	Valid

Based on the table to see the validation results presented above, we can see that the content validity and construct validity of the LKPD that was developed obtained mode 4 with valid criteria (Lutfi, 2021).

Practicality

Practicality is obtained from the results of the student response questionnaire and supported by the results of observations of student activities.

Table 7. Recapitulation of Learner Response Questionnaire

Aspects	Percentage	Category
Content	96,6%	Practical
Presentation	95,6%	Practical
Language	96,6%	Practical
Design	95%	Practical

Based on table 7, it is known that the worksheet with an AfL basis to improve the ability to solve problems on the material of acids and bases that was developed got a percentage of 96.2% with a practical category. In accordance with the Guttman scale, positive statements get a score of 1 with the answer "Yes" and a score of 0 if students answer "No". Conversely, if the statement is negative, it gets a score of 1 with the answer "No" and a score of 0 if students answer "Yes" (Riduwan, 2015).

Effectivenes

The effectiveness of worksheets to improve problem-solving skills is known from the results of the pretest and posttest. The data from the pretest and posttest results were processed througt the Ngain test.

The development of students' problem-solving abilities on the pretest and posttest indicates how effective the worksheet was. N-gain seeks to quantify the extent to which pupils' problem-solving skills have improved. The N-gain pre-test and post-test results for students' problem-solving abilities are shown in the Figure 9.

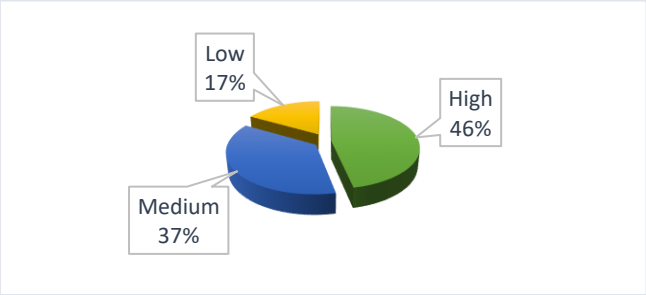

Figure 9N-gain Pretest and Posttest Result

Based on the figure above, the N-gain results from the pre-test and post-test of students are 14 in the high category, 11 in the medium category, and 5 in the low category. So an increase in students' problem solving skills was obtained after using the AfL worksheet.

N-gain aims to know the magnitude of influence in improving students' problem-solving abilities. The following is a table of the results of the N-gain pre-test & post-test of abilities related to student problem solving. The results of the N-gain test can be seen in the table below:

Table 8. SPSS Results of N-gain Test

	N	Minimum	Maximum	mean	Std. Deviation
Ngain	30	.00	1.00	.6591	.29428
Valid N (listwise)	30				

Based on the results of the table above, N shows the number of data, which is 30 data. Then, the n-Gain value ranges from 0 to 1. Where if the n-Gain result is 0.00, the pretest and posttest scores are the same or there is no increase, while if the n-Gain value is 1, the posttest has experienced a maximum increase. In the table, the minimum value is 0.00, which means that there are students who do not experience an increase in the pretest and posttest scores. Meanwhile, the maximum value is 1.00, which means that there are students who experience a maximum increase in the pretest and posttest scores. While the mean value of 0.6591 indicates an increase that is considered quite good overall. The mean n-Gain value of 0.6591 means that $0.7 > 0.6591 \geq 0.3$ is in the moderate category (Hake, 1999). This indicates that problem-solving skills are said to have been successfully improved with post-test results being higher than pre-test results and an N-gain value of $0.7 > 0.6591 \geq 0.3$ which is in the moderate criteria.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that this study has succeeded in developing a product in the form of an Assessment for Learning-based worksheet that aims to improve students' problem-solving abilities in the Acids and Bases material for grade XII of SMA. The worksheet developed is declared suitable for use as a learning medium because it has met the eligibility criteria in terms of validity, practicality, and effectiveness. From the validation results carried out by three validators, the worksheet obtained a score mode of 4 on the aspects of content and construct validity, which indicates that this worksheet is in the valid category. The practicality of the worksheet is also seen from the results of the questionnaire given to 30 students of grade XII-9 of SMAN 14 Surabaya with a result of 92.61% which is included in the practical category. In addition, the results of observations of

student activities by three observers showed a level of practicality of 97.2% which is also included in the very practical category. In terms of effectiveness, the analysis of the pretest and posttest results showed that the average N-gain value of 0.6591 indicated that the increase in students' problem-solving abilities was in the moderate category. Thus, it can be concluded that this Assessment for Learning-based worksheet is valid, practical, and effective for use in learning to improve students' problem-solving abilities in the Acids and Bases material.

RECOMMENDATIONS

Assessment for Learning (AfL)-based worksheet products are declared suitable for improving students' problem-solving abilities, especially in the acid and base material, salt hydrolysis sub-material.

ACKNOWLEDGEMENTS

Thanks are due to the supervisor and examiner lecturers and teachers at SMAN 14 Surabaya who have played a role in developing this worksheet.

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