Development of Student Worksheets Problem Solving Oriented to Train Metacognitive Skills Students Grade XI on Acid Base Materials

Dian Zulfatur Rizqiyah & Utiya Azizah*

Department of Chemistry Education, FMIPA, Universitas Negeri Surabaya, Jl. Ketintang Gedung D1, Surabaya, Indonesia 60231

* Corresponding Author e-mail*: utiyaazizah@unesa.ac.id

Abstract

This study aimed to describe the feasibility of student worksheets with problem solving oriented to train metacognitive skills on acid base material. The feasibility of student worksheets developed in terms of aspects, namely validity, practicality, and effectiveness. The type of this research used Borg and Gall Research and Development (R&D), and the design of this research used one group pretest-posttest design with the objects are 24 students on 11th grade in science 2 of SMAN 1 Dawarblandong. The results showed that the student worksheets were declared feasible of the validity, practicality, and effectiveness. The validity was measured by the content and construct validation sheets. The practicality was measured by the students' responses and average observation of students' activities. The effectiveness was measured by pretest-posttest of metacognitive skills, knowledge domain test, and supported by the metacognitive inventory questionnaire. The percentage of content validity from each students' worksheets is 87,78%. Construct validity obtained a percentage from each students' worksheets is 86,67%. The results of students' responses obtained an average percentage of 94,00% in the very practical category and was supported by the results of observations of students' activities by obtaining the percentage of relevant activities at meetings 1, 2, and 3 respectively 93.32%; 93.32%; and 96.65%. The results of students' metacognitive skills tests increased with a range of N-gain scores of 0.67 to 1.00 in the medium to high category. The knowledge domain test increased with a range of N-gain scores of 0.67 to 1.00 and was supported by the results of the metacognitive inventory questionnaire which obtained an average of 84.53 in the very good category. Based on the three aspects of the feasibility of the students' worksheets above, it can be concluded that the problem solving oriented to train students' metacognitive skills in acid-base material is feasible to use.

INTRODUCTION

Education in National Education System is an effort to produce a learning atmosphere and learning process. So that students actively develop the potential that exists within them. Various solutions and special attentions are given to the development and progress of education in order to repair the quality of education. With a good education, competent humans are also created (Mardhiyah et al., 2021). If quality education has been realized, our country will produce quality human resources. Quality education requires a curriculum. The curriculum that has been applied in Indonesia is very diverse, including the enactment of the 2013 curriculum. The 2013 curriculum was developed by improving the way of thinking by making learning student-centered. With the centering of learning on students, it is expected that the activeness and

independence of students will increase during learning activities, so that students are able to understand what has been learned and what will be learned (Permendikbud, 2013). This corresponds to the characteristic of metacognitive skills, namely awareness of what has been understood and what has not been understood (Anderson et al., 2001).

Metacognitive skills are knowledge related to cognitive awareness, human learning. A person thinks by creating a mental expression through the way of change or transformation of information that requires complex relationships with mental processes such as problem solving, consideration and imagination (Hanun & Azizah, 2022). Pulmones (2007) states that planning skills can help students solve problems through thinking activities and writing known and unknown information on the problem and writing down the goals to be achieved on the problem by involving the students' thinking process to find out the initial knowledge they have. According to Pulmones (2007), monitoring skills are the ability to solve problems by looking back at solutions to problems presented by reading the material repeatedly until they understand and check the problem-solving process with the right purpose. While evaluating skills are skills to evaluate the learning process which is shown by checking the achievement of learning goals. Some learners have difficulty in learning chemistry subjects. Chemistry has many complex, abstract concepts that must be gradually and thoroughly understood to be mastered. In chemistry, interrelated notions frequently arise that call for profound conceptions to achieve precise and straightforward understanding (Azizah & Nasrudin, 2018).

Based on reviewing the results of the initial research conducted by researchers at SMAN 1 Dawarblandong on January 4, 2023, as many as 77.8% of students consider that acid-base material is difficult to understand. The method of delivering material by educators at SMAN 1 Dawarblandong when giving acid-base material 88.9% still uses the lecture method. Pre-research conducted by researchers is to find information about material that is considered difficult, how to teach by educators, and also the initial metacognitive skills of students. The metacognitive skills of students at SMAN 1 Dawarblandong are still at a low stage in several metacognitive components, for example at the planning stage as many as 54.41% of students have not been able to plan an activity that helps them write information in a problem. Other metacognitive stages, namely monitoring and *evaluating*, are also still low. As many as 35.29% at the *monitoring* stage students still cannot solve a problem themselves and 20.59% at the stage of evaluating students still find it difficult to reflect on the learning strategies that have been used. From the result of pre-research, learning an innovation is needed in delivering material or it can be with a learning model that not only teachers are actively involved, but also the way students look at the information and concepts learned so that it will be meaningful and easy to understand and remember by students (Novita et al., 2012).

In research resulted that the problem solving learning model can train the metacognitive skills of learners (Nuzulul et al., 2017). Problem-solving-based learning is an activity designed by educators with the aim that students feel challenged through tasks and problems based on the material that has been taught so that students are able to make their own ways of solving. In research conducted by Azizah, Nasrudin and Rusmini showed that the problem-solving learning model was able to have an impact on students in the form of increasing students' thinking skills which means students' academic achievement abilities increased (Azizah et al., 2019). A learning model also requires the use of appropriate learning materials. Therefore, educators are expected to develop teaching materials as learning resources. One of the materials for study is student worksheets or namely as LKPD. Student worksheets as a learning resource are able to increase student activeness in the process in the classroom and student independence in completing daily tasks, so that student learning outcomes can increase (Fitria et al., 2020). Students worksheets is a printed teaching material that contains material to be studied, material summary, and how to using students worksheets related to tasks that must be completed by students that refer to the basic competencies achieved (Prastowo, 2011).

Problem solving requires students to find and solve a problem in group and individual learning in learning activities in order to achieve teaching objectives (Ulandari et al., 2015). This is accompanied by the research from Dewi and Azizah (2019) entitled "Development of Problem-Solving Oriented Student Worksheets to Train Students' Critical Thinking Skills on Chemical Equilibrium Material." The purpose of this study is to describe the feasibility of problem-solving oriented student worksheets to practice critical thinking skills on chemical equilibrium material. The results obtained from the study are problem solving oriented students worksheets can be said to be feasible in improving the skills of students in terms of validity, effectiveness, and practicality of the students worksheets (Dewi & Azizah, 2019). In research conducted by Azizah and Nasrudin, learning using teaching materials based on metacognitive skills can improve metacognitive skills. With these findings, it shows that in practicing metacognitive skills learners are able to make learners aware of learning, can plan their learning, control the learning process, evaluate the extent of the abilities possessed by the learners themselves and reflect on the learning carried out including the weaknesses and strengths they have (Azizah & Nasrudin, 2021).

The explanation that has been presented above, this requires that existence of feasibility test which includes the validity, practicality, and effectiveness of students' worksheets problem solving oriented to train metacognitive skills in acid base material.

METHOD

The research method used Research and Development (R&D) Borg and Gall. The research design revealed by Sugiyono (2015) has 10 steps, as follows: 1) Potential and problems, 2) Data collection, 3) Product design, 4) Design validation, 5) Design revision, 6) Product trial, 7) Product revision, 8) Usage trial, 9) Product revision, 10) Mass production. However, this study only carried out until the product trial stage to produce LKPD.
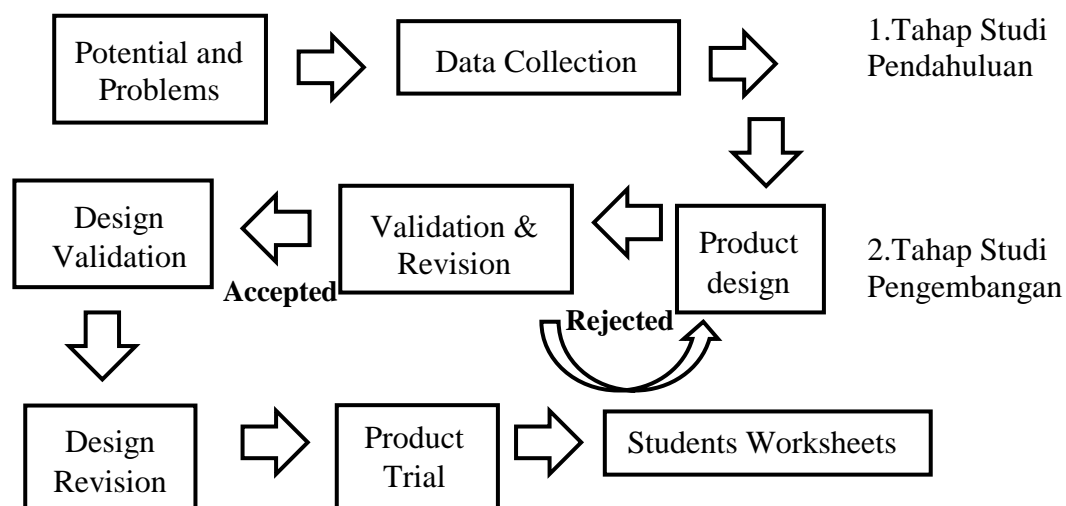

Figure 1. Steps of LKPD Development Research Methods oriented to Problem Solving to Train Metacognitive Skills of Students on Acid-Base Material

This trial uses the One Group Pretest Posttest Design method which is an experiment conducted on one group without a comparison group. The pattern of research conducted is:

$$O_1 \; X \; O_2$$

Figure 2. Media Trial Design (Sugiyono, 2015)

Additional Captions:
O_1= Pretest; X= Research Treatment; O_2 = Posttest

In this study there are three data collection techniques that will be used, including: observation, tests, and questionnaire. The observation method used to collect data on student activity observation sheets. Every observer observes student activities every 3 minutes during learning activities. Student activities are considered reasonable and support the effectiveness of problem-solving oriented student worksheets if the percentage of irrelevant student activities is lower than relevant student activities (Riduwan, 2015).

The test method is used to determine the effectiveness of problem solving oriented students worksheets to train students' metacognitive skills on acid-base material. In this study using 2 tests, namely: Metacognitive Skills Test Sheet and Knowledge Domain Test Sheet. After pretest and posttest data of metacognitive skills of students are collected, then a T test is given with paired sample T-test. But before the T test, the pretest and posttest data must be normalized first using SPSS with the Kolmogorof Smirnov test. Data can be said to be normal if it is significant >0.5 which means that the data is normally distributed. After the results show that the data is said to be normally distributed, then n-gain score analysis is carried out. Knowledge domain tests are obtained from the pretest and posttest and then analyzed using the n-gain score.

Table 1. N-Gain Score Category

Interval Nilai	Criteria
5	Very good
4	Good
3	Enough

(Hake, 1998)

From the data of the N-gain score analysis that has been carried out, problem-solving-oriented students worksheets can be declared effective if one by one of students obtain n-gain score of $0.7 > g \geq 0.3$ in the medium category or $g \geq 0.7$ in the high category (Hake, 1998).

The questionnaire method used in this study includes three, namely: Study Sheet Questionnaire and Students Worksheet Validation, Study Sheet Questionnaire and Validation of Learning Tools and Research Instruments, and Student Response Questionnaire. Validators will give an assessment score in the range 1-5 on the validation sheet. Below is the likert scale range used in determining values during validation:

Table 2. Likert Scale

Interval Nilai	Criteria
5	Very good
4	Good
3	Enough
2	Bad
1	Very Bad

(Riduwan, 2015)

And then calculated by using this formula:

$$\text{Validity (\%)} = \frac{\text{Total Score}}{\text{Criteria Score}} \text{ x } 100$$

The results of the validity score assessment are then interpreted using development validity criteria as in the Table 3. Based on the categories in table, students worksheet problem-solving-oriented, it is said to be valid if the validity of the content and construct each obtain a percentage of $\geq 61\%$ which is described as valid (Riduwan, 2015). The Student Response Questionnaire made answer choices "Yes" and "No"and determined from calculations using the Guttman scale score (Table 4).

Table 3. Categories Score Interpretation

Interval Nilai	Criteria
81% - 100%	Very valid
61% - 80%	Valid
41% - 60%	Valid Enough
21%-40%	Not Enough Valid
0%- 20%	Invalid

(Riduwan, 2015)

Table 4. Guttman Scale

Statement	Positive Statement	Negative Statement
Yes	1	0
No	0	1

(Riduwan, 2015)

The data obtained is calculated using the formula below:

$$Percentage = \frac{Total\ Score}{Total\ Respondent}\ x\ 100\%$$

(Riduwan, 2015)

The percentage of student response questionnaire results is then interpreted according to this Table 5.

Table 5. Categories Score Interpretation

Interval Nilai	Criteria
81% - 100%	Very Good
61% - 80%	Good
41% - 60%	Enough
21%-40%	Bad
0%- 20%	Very Bad

(Riduwan, 2015)

Based on the categories in table 5, problem-solving-oriented students worksheets is said to be practical if the results of student response questionnaires obtain a percentage of ≥61% which is described as in good condition (Riduwan, 2015)

RESULTS AND DISCUSSION

Preliminary Study Phase

This stage is divided into identifying potentials and problems, and collecting data at SMAN 1 Dawarblandong in class XI Science 2 covering the conditions of students, teachers, and the school environment related to problem-solving students worksheets development research to train students' metacognitive skills on acid-base material.

Identifying problems is done to obtain important information by conducting pre-research and interviews. Pre-research conducted on students of grade XII Science 3 SMAN 1 Dawarblandong by providing several questions about what material is considered difficult by students, teaching methods used by educators during the learning process and teaching media used in learning. Pre-research results show that chemicals are considered quite difficult, especially acid-base, lack of practicum activities. In relation to the description of problems that have been observed by researchers, researchers develop problem-solving-oriented students worksheets that can train students' metacognitive skills on acid-base material. Potentials and

problems obtained from observation and interview activities are used as one of the bases in writing research background.

After exploring the problems and potentials in the school, the next stage is to collect data and information. Collect data and information in the form of theories sourced from books, journals, articles and from previous research which includes the development of students worksheets, metacognitive skills, *problem solving learning models*, and acid-base materials. The purpose of collecting this data and information is to design materials for the initial students worksheets oriented *problem solving and* overcome existing problems at the stage of discovery of potential and problems.

The students worksheets developed using acid-base material. Providing acid-base material to students requires a learning model where students can be actively involved in mastering the knowledge or concepts learned, so that it will be more meaningful and easier for students to understand and remember (Novita et al., 2012).

Development Study Phase

At this development study stage, it aims to produce products, namely students worksheets that are developed that are useful and can be used to support the chemistry learning process. The students worksheets developed is based on the results of studies by chemistry lecturers and validation results by chemistry lecturers and teachers which will then be tested on grade XI Science 2 students at SMAN 1 Dawarblandong. Each students worksheets developed has three frameworks, namely introduction, content and closing. The introduction includes: cover at the beginning, table of contents, concept map, basic competencies, indicators of competency achievement and learning objectives. The content includes: phenomena or problems to be solved, practicum activities, assessment questions related to the phenomena provided and application questions. While the closing section there is a bibliography as a reference source that exists in the entire students worksheets.
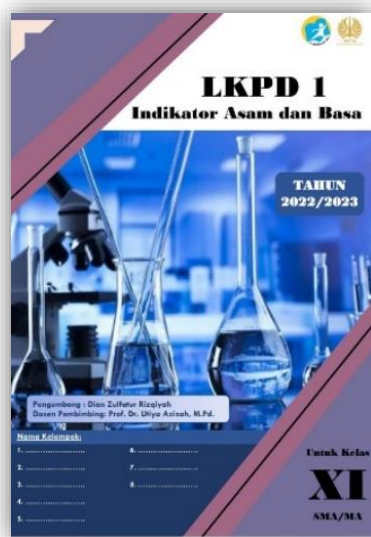

Figure 3. One of Students Worksheets Cover

Validity

Based on the results of the validation that has been carried out on each problem-solving-oriented students worksheets, data is obtained from all aspects of the validity of the content, namely getting a valid or very valid category. The validity of the contents of the developed students worksheets includes the suitability of basic competencies with indicators of

competency achievement to be achieved, the suitability of acid-base material with indicators and objectives, the truth of phenomena with the material, the suitability of the contents of students worksheets with the *problem solving* learning model, the suitability of the contents of students worksheets with metacognitive skill criteria, and students worksheets is able to improve the scientific attitude of students. students worksheets 1, 2, and 3 have a percentage of validity of students worksheets content of 87.78% with very valid categories.

The criteria for construct validation according to the Ministry of National Education (2008) are linguistic, presentation, and graphic criteria. In the linguistic criteria, the aspects assessed are writing using terms that are easy to understand, writing students worksheets using short and easy-to-understand language, writing students worksheets using good and correct Indonesian, and writing students worksheets using active and efficient language. In the presentation criteria, the aspects assessed are the presentation of students worksheets containing clarity of purpose, the order of material in the students worksheets is systematic, the presentation of images is appropriate, the presentation of students worksheets arouses the motivation and curiosity of students, the presentation of material encourages students to be actively involved, the presentation of images accompanied by references, the presentation of students worksheets is interesting or fun.

On the graphic criteria, the aspects assessed are attractive covers and presenting students worksheets, the use of font types and text sizes used to make it easier for readers to use students worksheets, compatibility of text and image layouts on students worksheets, and graphic illustrations, images and photos. It can be seen in table 16 which shows that students worksheets 1, 2, and 3 have a percentage of validity of students worksheets content of 86.67% with very valid categories.

Worksheet Trials (Practicality and Effectiveness)

Students worksheets trials conducted on a limited basis are the final stage in the development study stage. The aim is to obtain data on the practicality and effectiveness of students worksheets used in the implementation of trials. This limited trial is carried out after the students worksheets has gone through a process of improvement and refinement and validation has been declared valid. The following is the schedule of trials that have been carried out by researchers in class XI Science 2 SMAN 1 Dawarblandong.

During the limited trial activities of students worksheets, results were obtained in the form of metacognitive skills pretest results, observations of student activities at the 1st, 2nd, 3rd meetings, metacognitive skills posttest results, student response results to students worksheets, and student metacognitive inventory questionnaire results. The data obtained is then used to determine the feasibility of students worksheets which includes the practicality and effectiveness of students worksheets.

The practicality of LKPD can be seen from the results of student response questionnaires and observation sheets of student activities. The students response questionnaire was given to students at the end of the meeting after the *posttest* was over, namely Friday, May 5, 2023 with a total of 24 respondents as many as 24 students of grade XI Science 2 SMAN 1 Dawarblandong. The response questionnaire distributed to students contained 17 questions.

The results obtained stated that each aspect assessed obtained a percentage of ≥82.80% while the average of all aspects assessed was 94%, meaning that the LKPD developed was very practical and easy to use. Data from the analysis of student response questionnaires with an average percentage of ≥61% are included in the practical or very practical category (Riduwan, 2015).

Table 6. Data of Student Responses

No.	Aspect	Percentage	Categories
1.	Content	89,00%	Very Practical
2.	Linguistic	98,00%	Very Practical
3.	Presentation	86,13%	Very Practical
4.	Graphic	93,73%	Very Practical

The observation sheets of student activities are handled by the observers. They observe every three minutes. the results of observations of student activities by obtaining the percentage of relevant activities at meetings 1, 2, and 3 respectively was 93.32%; 93,32%; and 96.65%. The overall percentage of relevant activities from the three meetings obtained greater than irrelevant activities, so that student activities were carried out well and could support the practicality of problem-solving oriented LKPD that had been developed by researchers. This is in accordance with research conducted by Hanun and Azizah that in their research shows that learners experience improvement and are highly involved in learning (Hanun & Azizah, 2022).

The effectiveness of this learning model is evaluated based on the achievement of problem-solving thinking skills which is the instructional influence of the material implementation (Azizah & Nasrudin, 2022).. The effectiveness of LKPD can be known from the results of the pretest posttest metacognitive skills of students, the results of the knowledge domain test, and supported by the results of the metacognitive inventory questionnaire of students. Metacognitive skills and knowledge domain tests were measured through tests before LKPD trials (pretest) and tests after LKPD trials (posttest). A metacognitive inventory questionnaire was given to each learner at the last meeting along with the posttest schedule. The following is data on metacognitive skills test results.
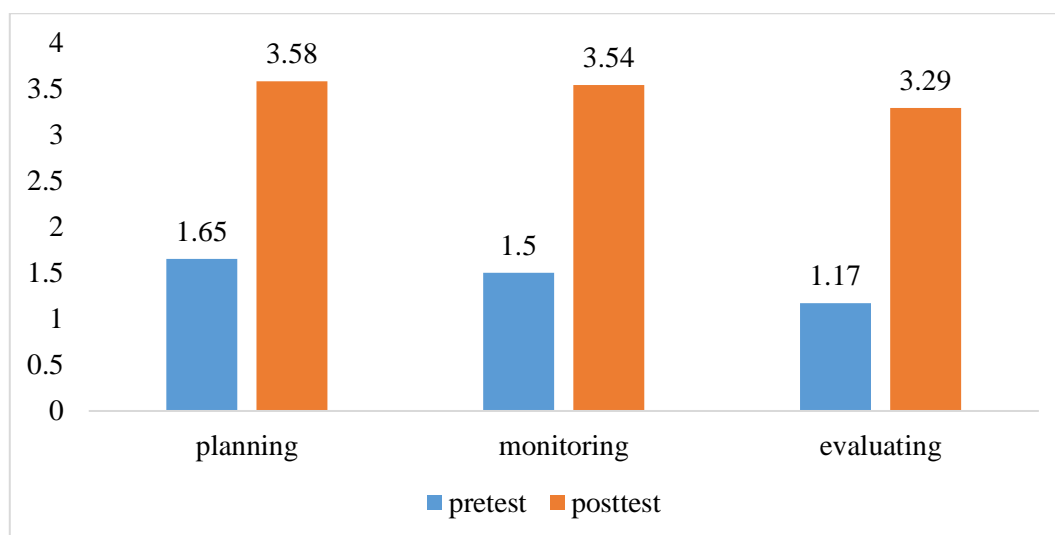

Figure 4. Diagram Improvement of Each Component Metacognitive Skills

The Figure 4 shows that each component of students' metacognitive skills improved after limited trials of developed LKPD. The blue chart is the pretest and the orange chart is the posttest. Planning skills on the pretest was 1.65 and increased the average posttest to 3.58, the monitoring skills component on the pretest was 1.5 and increased the average posttest to 3.54, while the evaluating skills component obtained an average pretest result of 1.17 and increased The posttest average was 3.29. Pretest *and* posttest *data* are normalized first. The results of data normalization are presented in the table 7. Its shows that the normality test obtained a Sig. (2-tailed) value of 0.200>0.5, so it can be said that both data (pretest and posttest) are normally distributed. After the data is normally distributed, the data is then tested N-gain score to determine the difference between pretest and posttest values.

Table 7. Normality Test Results

One-Sample Kolmogorov-Smirnov Test		
		Unstandardized Residual
N		24
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	561.05302444
Most Extreme Differences	Absolute	.133
	Positive	.133
	Negative	-.113
Test Statistic		.133
Asymp. Sig. (2-tailed)		.200[c,d]

After being tested with *N-gain score,* pretest *and* posttest *data* were carried out in pairs to determine a significant difference between the two data. The paired T test is carried out using a parametric test, namely the paired *sample t-test*. The *paired sample t-test* is performed with the help of SPSS 22. The following are the paired sample t-test results (Table 8).

Table 8. The Paired Sample T-Test Results

		Paired Samples Test							
		Paired Differences							Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	
					Lower	Upper			
Pair1	Pretest-posttest	-5026.04167	792.26832	161.72109	-5360.58724	-4691.49610	-31.078	23	.000

The table above, shows that *pretest-posttest* metacognitive skills obtain sig scores. (2- tailed) 0.000<0.05 so that H_0 is rejected. In the parametric test results obtained, it can be concluded that there is an influence from the application of problem-solving-oriented LKPD to train students' metacognitive skills on acid-base material. It also states that LKPD is problem-solving-oriented effective for training learners' metacognitive skills on acid-base material.

In addition to the skill test, data on the effectiveness of student LKPD was obtained from the knowledge domain test and supported by a metacognitive inventory questionnaire sheet that was distributed to each student at the end of the meeting. In the results of the knowledge field test, the n-gain value obtained by students is shown. Learners acquire medium and high categories. 54.17% of students obtained the high category and 45.83 obtained the medium category. All students can be said to be complete because the value achieved is ≥75 in accordance with the specified KKM.

The inventory questionnaire sheet was adapted by Schraw and Dennison (1994). Metacognitive skills of students are said to be well trained if they get a score of ≥61 in the good or very good category. The percentage of average results of the students' metacognitive inventory questionnaire scores in each component is as follows in Figure 6.

Figure 6. below shows that the highest metacognitive inventory value is obtained in the *evaluating* skills component and the lowest average is obtained in the *planning skills* component. This result is also in line with the results of the metacognitive skills test where the *evaluating skills component* obtained the highest average compared to other metacognitive skills components. The results obtained can be concluded that LKPD is problem-solving-oriented effective for training students' metacognitive skills on acid-base material.
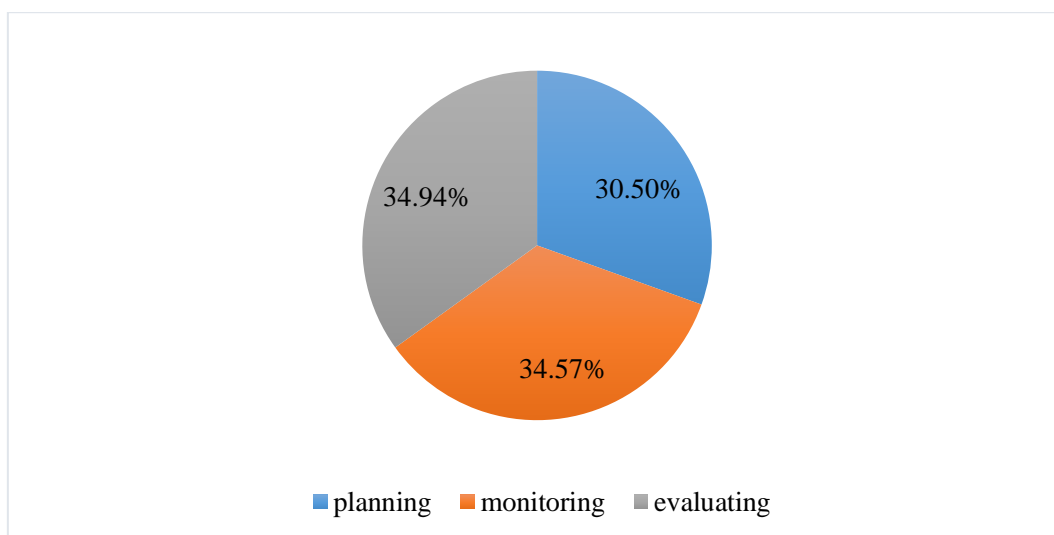
Figure 5. Average Yield Percentage of MAI Questionnaire for Each Component

CONCLUSION

Based on the results of research and discussion of problem-solving-oriented students worksheets to train students' metacognitive skills on acid-base material in terms of validity, practicality, and effectiveness, it can be concluded that: The results of validity in terms of content validity and construct validity, the developed students worksheets is declared valid. This is because the validity of the contents in students worksheets 1, 2, and 3 obtained an average score of 87.78%. Meanwhile, construct validity in each students worksheets 1, 2, and 3 obtained an average score of 86.67% with valid or very valid categories. Practicality in terms of student responses and supported by observations of student activities, the developed students worksheets is practical to use. This is because the results of student responses to the developed students worksheets obtained an average percentage of 94% with a very practical category and supported by the results of observations of student activities by obtaining the percentage of relevant activities at meetings 1, 2, and 3 respectively was 93.32%; 93,32%; and 96.65%.

The effectiveness in terms of the results of metacognitive skill tests, knowledge domain tests and supported by metacognitive inventory questionnaires, the students worksheets developed were declared effective for use. This is because the results of the metacognitive skills test of students have increased with a *N-gain score* range of 0.67 to 1.00 in the medium to high category. The knowledge domain test increased with a *N-gain score* range of 0.67 to 1.00 and was supported by the results of the metacognitive inventory questionnaire which obtained an average of 84.53 in the very good category. Based on the three feasibility aspects of students worksheets above, it can be concluded that students worksheets is problem-solving-oriented to train students' metacognitive skills on acid-base material suitable for use.

RECOMMENDATIONS

Based on the results of data analysis and conclusions, several suggestions can be put forward including: The limited trial time on problem-solving-oriented students worksheets to practice metacognitive skills needs to be extended again, so that the metacognitive skills taught can improve in each component. Because based on research that has been carried out by researchers, metacognitive skills need to be familiarized continuously in the long term and consistently, The development of problem-solving-oriented students worksheets to train

students' metacognitive skills can be applied to other chemical materials so that students' metacognitive skills can be well trained.

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