24 (1), 2023, 310-323

Jurnal Pendidikan MIPA

e-ISSN: 2685-5488 | p-ISSN: 1411-2531

http://jurnal.fkip.unila.ac.id/index.php/jpmipa/

Development of Guided Inquiry-Oriented Worksheets to Improve Students' Metacognitive Skills on Acid-Base Material

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Abstract: Improving students' metacognitive skills is needed to improve the quality of education in Indonesia. The purpose of this study was to develop guided inquiry-oriented student worksheets to assist students in improving metacognitive skills on acid-base materials. The Borg and Gall model was used in this research method. The instruments used were the validation sheet, student response questionnaire, student activity observation sheet, metacognitive skills pretest-posttest questionnaire, and metacognitive inventory questionnaire. The subjects of this study amounted to 22 students of class XI IPA 1 SMAN 1 Dawarblandong. The worksheets developed were very valid with the average results of content validity on students' worksheets 1, 2, and 3 of 4.67; 4.56; 4.56, and construct validity on students' worksheets 1, 2, and 3 of 4.63. The practicality of the student worksheet obtained a percentage of 93.2% in the very practical category. The student worksheet was assessed for effectiveness using the N-gain test and paired sample t-test on pretest-posttest results. The average N-gain was 0.63 with a medium category and sig (2-tailed) value of 0.000 <0.05. Based on these findings, it can be said that the guided inquiry-oriented student worksheets are valid, very practical, and effective in helping students improve their metacognitive skills.

Keywords: students' worksheet, guided inquiry, metacognitive skills, acid-base.

Abstrak: *Peningkatan keterampilan metakognitif siswa sangat diperlukan untuk meningkatkan kualitas pendidikan di Indonesia. Tujuan dari penelitian ini adalah untuk mengembangkan lembar kerja siswa yang berorientasi pada inkuiri terbimbing untuk membantu siswa dalam meningkatkan keterampilan metakognitif pada materi asam basa. Model Borg and Gall digunakan dalam penelitian ini. Instrumen yang digunakan adalah lembar validasi, angket respon siswa, lembar observasi aktivitas siswa, angket pretest-posttest keterampilan metakognitif, dan angket inventori metakognitif. Subjek penelitian ini berjumlah 22 siswa kelas XI IPA 1 SMAN 1 Dawarblandong. Lembar kerja siswa yang dikembangkan sangat valid dengan hasil rata-rata validitas isi pada lembar kerja siswa 1, 2, dan 3 sebesar 4,67; 4,56; 4,56 dan validitas konstruk pada lembar kerja siswa 1, 2, dan 3 sebesar 4,63. Kepraktisan lembar kerja siswa memperoleh persentase sebesar 93,2% berkategori sangat praktis. Lembar kerja siswa dinilai efektivitasnya dengan menggunakan uji N-gain dan paired sample t-test pada hasil pretest-posttest. Rata-rata N-gain sebesar 0,63 dengan kategori sedang dan nilai sig (2-tailed) 0,000 < 0,05. Berdasarkan temuan ini, dapat dikatakan bahwa lembar kerja siswa berorientasi inkuiri terbimbing valid, sangat praktis, dan efektif dalam membantu siswa meningkatkan keterampilan metakognitif mereka.*

Kata kunci: *lembar kerja siswa, inkuiri terbimbing, keterampilan metakognitif, asam basa.*

▪ INTRODUCTION

A country can continue to develop with the role of education. A nation will lag far behind other nations without education. The Political and Economic Risk Consultant (PERC) has evaluated Indonesia's educational system as the 12th best in Asia out of 12 countries. Law No. 20 of 2003 states that Article 3 of the National Education System

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DOI: http://dx.doi.org/10.23960/jpmipa/v24i1.pp310-323
Received: 14 April 2022
Accepted: 20 June 2022
Published: 29 June 2022

aims to develop the ability and shape the character and civilization of a dignified nation in order to educate the nation's life, aims to develop the potential of students to become human beings who are faithful and devoted to God Almighty, noble, healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizens. Changing Indonesia's current education system and improving the quality of education are efforts to achieve these goals (Usman, 2014).

The revised 2013 curriculum is one of the applicable curricula that need to be adjusted as part of the implementation of the education system. One of the schools that still applies the revised 2013 curriculum is SMAN 1 Dawarblandong. Permendikbud Number 35 of 2018 states that student-centered learning patterns are used in the development of the 2013 curriculum. To comprehend the learning strategies to be employed and the notion of the content acquired during learning, students are encouraged to be more active and independent during the learning process. This fits in with the traits of metacognitive skills, specifically how pupils can reflect on their thinking and their ability to effectively use particular learning strategies (Slavin, 2018). With the existence of metacognitive skills, students will learn independently in solving problems (Abdelrahman, 2020). Metacognitive skills are simply defined as thinking (Jaleel & Premachandran, 2016).

Metacognitive skills can reflect students in planning, implementing, and monitoring strategies and assessing their work (Azizah & Nasrudin, 2018; Carvalho & Santos, 2022). Metacognitive skills are needed in learning (Mahdavi, 2014; Halim, et al., 2018; Suganthi, Anwar & Muthurasu, 2020). Metacognitive skills can help students to improve learning outcomes (Widyawati & Nasrudin, 2019). Improved learning outcomes show that the education system in Indonesia is improving (Putri A., 2019). Based on the results of a pre-study questionnaire given to 35 students at SMAN 1 Dawarblandong on January 4, 2023, students' metacognitive skills in the planning, monitoring, and evaluation components were 68.6%, 60%, and 51.4%. This finding explains that the students of SMAN 1 Dawarblandong are not accustomed to using metacognitive skills.

Chemistry is a science that examines a substance's composition, nature, changes in composition or nature, and energy changes that take place when a substance changes (Azizah, et al., 2017). Based on the pre-research questionnaire filled out by students at SMAN 1 Dawarblandong, 68.6% of students said that chemistry is a tough subject to understand, and up to 60% of students said that acid-base is a challenging chemical concept. Students have trouble grasping the idea of microscopic acid-base materials, such as the representation of particles in a solution that change color when tested with an acid-base indicator. This is consistent with the study by Brilian, et al. (2018) that shows students often struggle to understand acid-base content since it contains all three levels of macroscopic, microscopic, and symbolic representations. According to Permendikbud Number 37 of 2018, the basic competencies that must be achieved are KD 3.10 explaining the concept of acid-base and its strength and ionizing equilibrium in solution, and 4.10 analyzing the trajectory of pH changes of several indicators extracted from natural materials through experiments. Metacognitive skills are required in acid-base material because this basic competency requires students to participate actively and autonomously in learning activities by conducting an experiment to identify acid and base solutions so that students can understand the learning strategies that will be used to

build their comprehension (Slavin, 2018). Metacognitive skills are one aspect to build students' understanding of chemistry (syahmani, Saadi, Clarita, & Sholahuddin, 2021). following the statement of Junina, et al. (2020) that metacognitive skills must be practiced frequently to measure students' understanding of learning.

One of the learning models that can motivate students to actively participate in conducting experiments is the guided inquiry learning model (Adnan & Bahri, 2018). Guided inquiry is more efficient in providing direct experience to students compared to the transfer of information in a regular classroom (Orosz, Nemeth, Kovacs, Somogyi, & Korom, 2023). The guided inquiry learning model places a strong emphasis on student participation in the learning process. This is consistent with one of the fundamental ideas of learning psychology, which holds that students learn more effectively the more actively they participate in the learning process (Izzah & Azizah, 2019). The results of the guided inquiry learning model successfully improved students' metacognitive skills (Asy'ari, Ikhsan, & Muhali, 2019). This can be seen from the syntax of the inquiry learning model which emphasizes student involvement in conducting experiments to support hypotheses, collecting data, and analyzing experimental results using pre-existing theories that allow students to engage in critical thinking (Nurdyansyah & Fahyuni, 2016). Menggunakan model pembelajaran inkuiri terbimbing dengan strategi metakognitif dapat membantu siswa mengembangkan keterampilan metakognitif mereka (Nunaki, Damopolii, Kandowangko, & Nusantari, 2019).

The use of learning models requires modification of the use of appropriate teaching materials, so teachers are required to provide teaching materials as one of the learning resources. The effectiveness of the teaching and learning process is greatly influenced by the teacher's ability to provide teaching materials (Lestari, 2013). The creation of students' worksheets must be able to increase student motivation, self-efficacy, and confidence in their ability to learn (Hallinger, Hashemi, & Kouhsari, 2018). The development of students' worksheets integrated with metacognition will help students construct their abilities so that they become critical and reflective students who automatically become successful learners (Trisna, Budayasa, & Siswono, 2018). Worksheets for students can motivate them to participate actively in their education and give them additional options for how to complete tasks (Fitri, Wijaya, & Danial, 2020). Based on the data from filling out the pre-research questionnaire, 58.3% of students expect worksheets to contain material, practice questions, and phenomena that must be resolved through practice questions. Improved student learning outcomes can be achieved by incorporating environmental phenomena into learning materials (Abdurrahman, et al., 2020).

Based on the description of the problem, it is important to conduct research with the title "Development of Guided Inquiry-Oriented Worksheets to Improve Students' Metacognitive Skills on Acid-Base Material." This research is expected to produce students' worksheets that teachers can use to improve students' metacognitive skills.

▪ METHOD

Research Design

The research and development method (R&D) was used in this research design. The research and development (R&D) method is an examination strategy used to produce certain products and test the validity, practicality, and effectiveness of these

products. According to Borg and Gall (Sugiyono, 2016), research and development consist of ten steps which include: (1) Identification of potential and problems, (2) Data collection and literature study, (3) Product design, (4) Design validation, (5) Product design revision, (6) Product trial, (7) Product revision, (8) Usage trial, (9) Product revision (10) Mass production. This research is only limited to product trials to produce student worksheets. The subjects in this study were 22 students of class XI IPA 1 SMAN 1 Dawarblandong. The data sources of this study were obtained from validators, observers, and 22 students of class XI IPA 1 SMAN 1 Dawarblandong. During the product trial, a one-group pretest-posttest design was used.

Research Instruments

In conducting research, a research instrument is needed. A research instrument is a measuring tool for phenomena or problems that are specifically observed and studied (Arikunto, 2019). The validation sheet, student response questionnaire, student activity observation sheet, metacognitive skills pretest-posttest sheet, and metacognitive inventory questionnaire are the instruments used in this study. All research instruments were validated by three validators and received a valid category with an average score of >4.

The validation sheet was developed by the researcher with validation results of 5 categorized as very valid. Content, language, presentation, and images are the aspects assessed on the validation sheet. The validation sheet was made using the standard criteria for making student worksheet, which includes content and construct validity. The student response questionnaire was developed by the researcher consisting of 16 positive questions and 4 negative questions regarding opinions or responses after using the student worksheet. The average validation score for the student response survey was 4.6 with a valid category. The student response questionnaire was used to assess the usefulness of the student worksheet in terms of content, language, presentation, and visuals. The average validation result for the student activity observation sheet instrument is 4.6 with a valid category. On the observation sheet, there are 16 activities to be observed, both relevant and irrelevant. The ability to plan, monitor, and evaluate, as well as other activities related to the application of the guided inquiry learning model, are examples of relevant activities. While irrelevant activities are activities that have nothing to do with learning, such as using the telephone. The learner activity observation sheet was developed by the researcher

The metacognitive skills pretest-posttest question sheet instrument consisted of five description questions with each question consisting of components of planning skills, monitoring skills, and evaluating skills. Questions on the planning skills component measured indicators, namely identifying to get information and writing learning objectives. Questions on the monitoring skills component measured indicators are solving problems, while questions on the evaluating skills component measured indicators are reflecting on the strategies used and identifying the best strategy. The pretest-posttest question sheet was developed by the researcher and obtained an average validation result of 4.5 with a valid category. The following instrument is a metacognitive inventory questionnaire adapted by Schraw and Dennison in 1994. The instrument has ten positive and ten negative questions that address three areas for improvement of metacognitive skills including planning, monitoring, and evaluation. Questions on the planning skills component consisted of six questions used to measure

indicators of identifying to get information, thinking and writing down what is known, and writing down learning objectives. Questions on the monitoring skills component consist of seven questions used to measure indicators of solving problems and making important notes from the information. While questions on the evaluating skills component consist of seven questions used to measure indicators of reflecting on the strategies used and identifying which strategies are the best, conducting learning assessments, and rechecking student understanding. With an average score of 5, the metacognitive inventory questionnaire obtained a very valid category.

Data Analysis Technique

Quantitative descriptive techniques are used to analyze data from validation results. On the validation sheet, the validators will enter a score according to the Likert scale with an assessment between 1 to 5. The validation result data is ordinal data that can be analyzed by determining the mode of each aspect assessed. the assessed aspect is said to be valid if it obtains a mode ≥3 and is said to be invalid if it has a mode value <3 (Lutfi, 2021).

The student worksheet consists of positive questions and negative questions with the intention that students read the questions carefully before answering the response questionnaire (Ni'mah & Hidayah, 2017). The percentage of student response questionnaires is determined using a Guttman scale score. on positive statements, a score of (1) is given if you give a "yes" answer and (0) if you give a "no" answer, while on negative questions a score of (0) is given to the answer "yes" and (1) if you give a no answer. Guided inquiry-oriented student worksheets are considered practical if the results of approved answers from students get ≥61% which is considered practical or very practical (Riduwan, 2015). Findings from observations of student activities conducted during the product trial confirmed the practicality of the student worksheets. Student activities are said to be well implemented if relevant student activities are more than irrelevant student activities. This supports the use of student worksheets that aim to improve students' metacognitive skills (Riduwan, 2015).

The improvement between the pretest and posttest scores on each learner's metacognitive skills and metacognitive skills inventory questionnaire demonstrates the effectiveness of student worksheets. Pretest and posttest questions get a score of 0-4 according to the scoring rubric on the pretest and posttest grids. The n-gain test and paired sample t-test can be used to determine the improvement in pretest-posttest scores. With the use of SPSS 22, the data were first checked for normality using the Kolmogorov-Smirnov test before being subjected to the n-gain test and paired sample t-test. Data is said to be normal if the significant value is> 0,05 (Putri R., 2020). Students' metacognitive skills are declared to have increased if the N-gain value obtained is in the medium ($0,3 \leq g \leq 0,7$) and high ($g > 0.7$) categories (Hake, 2002). The pretest-posttest data is further examined using the Paired Sample T-test on SPSS 22 to determine whether there is a significant difference between the pretest and post-test scores. If the student worksheet reaches a significant value of 0,05, the student worksheet is considered successful in improving metacognitive skills (Nuryadi, Astuti, Utami, & Budiantara, 2017).

▪ RESULT AND DISSCUSSION

Validity of Student Worksheet

Knowing whether the student worksheet is feasible or not in terms of validity is the purpose of validity (Mustafidah & Azizah, 2022). The validity of students' worksheet made includes content validity and construct validity in the form of language, presentation, and graphics based on the research results. The results obtained are presented in Table 1 below:

Table 1. Average of student worksheets validity results

Aspect Validity	Average Mode		
	LKPD 1	LKPD 2	LKPD 3
Content	4.67	4.56	4.56
Language	4.5	4.75	4.75
Presentation	4.75	4.5	4.5
Graphics	4.67	4.67	4.67

Data analysis in Table 1 shows that student worksheets 1, 2, and 3 have an average content validity score of 4,67, 4,56, and 4,56 with a valid category. This shows that overall student worksheets 1, 2, and 3 are following the revised 2013 curriculum and are following the syntax of the guided inquiry learning model, and contain indicators of improved metacognitive skills. This is in line with Depdiknas (2008), who asserts that instructional materials must be developed following the requirements of the relevant curriculum. In addition, the material in the student worksheet is following the learning objectives measured, so that it can develop students' ability to solve a problem (Khoiroh & Azizah, 2021).

For student worksheets 1, 2, and 3, obtaining construct validity results on the linguistic aspect resulted in an average score of 4,5, 4,75, and 4,75 with a valid category. Students' worksheet 1 obtained the lowest average score because there was still ineffective use of language that could lead to multiple interpretations. This is following the statement of Afridayanti and Azizah (2020) which states that the use of ineffective language will contain double meanings in sentences which can hinder teachers in teaching acid-base material to students. In the presentation aspect for students' worksheets 1, 2, and 3 consecutively obtained an average score of 4,75; 4,5; and 4,5 with the highest score obtained by students' worksheet 1. Meanwhile, in the graphic aspect, each student's worksheet obtained the same score of 4,67 with a valid category. This means that in the students' worksheet, the letters used can make it easier for users to read, the cover design used can attract readers' interest and match the content and has a color quality that can attract the attention of readers so that the students' worksheet developed has met the criteria of graphics. In line with the viewpoint expressed by Ramdoniati, et al. (2019), durability, form, and color are important considerations when selecting teaching materials.

Overall, the validity of the content, language, presentation, and graphics on each student's worksheet produced valid results; this is relevant to the research of Ain and Mitarlis (2020), which found that inquiry-oriented worksheets produced categories of content, language, presentation, and graphic validity.

The Practicality of Student Worksheet

The practicality of the student worksheets was assessed based on responses from students and observations of student interactions with the student worksheets made. Based on the survey results, 94,06% of respondents gave a positive assessment of the student worksheets that had been used, while 5,94% did not give a positive assessment. The language component obtained a positive response of 100%. The presentation component obtained a positive response of 87,88% and a negative response of 12,12%. The graphical aspect obtained a positive response of 88,64% and a negative response of 11,36%. Overall, the percentage of students who gave positive responses to each aspect was >87%. In the presentation aspect, the lowest percentage was obtained because the negative response of students stated that the explanation in the student worksheet was difficult to understand. However, most students can understand the explanation. Thus, it can be said that the student worksheets are practical to use. Following the statement of Prastowo (2012) which states that student worksheets can improve learning and help students understand what is being taught.

The results of observations of students participating in learning activities also prove the practicality of the developed student worksheets. Observations were conducted over three meetings and observed objectively by three observers. Relevant activities assessed by observers include the application of the guided inquiry learning model and indicators of metacognitive skills seen on student worksheets, in contrast to irrelevant activities, namely activities that occur when students do other activities when participating in learning activities. Student activity is a very important thing to do during learning activities. Rahman (2022), revealed that learning will not occur without student activity. The findings from the observation of the student's actions are shown in Table 2 below:

Table 2. Student activity observation results

Activities observed	Meeting I	Meeting II	Meeting III
Relevant Activity	83.52	85.02	86.09
Irrelevant Activity	16.48	14.98	13.91

Table 2 shows that at each meeting, relevant activities received a higher percentage of them than irrelevant ones. This result shows that students follow the learning very well so that students can find the concept of acid-base through guided inquiry-oriented student worksheets to improve students' metacognitive skills. Wahab, et al. (2021) supported these findings by stating how guided inquiry-oriented student worksheets can facilitate independent learning and improve student learning outcomes.

Effectiveness of Student Worksheet

The effectiveness of the student worksheets made was evaluated using the results of the pretest and posttest of metacognitive skills, as well as the results of the metacognitive questionnaire inventory given after learning by using the student worksheets made. Indicators of metacognitive skills trained in the study, namely, planning skills include: (1) identifying known information, (2) thinking and writing known information, and (3) writing learning objectives. Monitoring skills include: (1) making notes of important information, (2) solving problems. Evaluating skills include:

(1) conducting learning assessments, (2) reflecting on the learning strategies used and identifying which strategies are best, and (3) rechecking students' understanding of the material (Pulmones R., 2007). The findings from the pretest and posttest were examined using the N-gain score test and paired t-test. With the use of SPSS 22, the pretest-posttest data were first checked for normality using the Kolmogorov-Smirnov test. The normality test was carried out to ascertain if the data were regularly distributed the data were regularly distributed or not, the normality test was carried out. The results of the normality test revealed a Sig. (2-tailed) of 0,200> 0,5, indicating that both sets of data are regularly distributed. The data is examined for N-gain score to measure the increase between pretest and posttest scores once the normality test is completed and it is determined that the data is normally distributed. Table 3 below shows the N-gain score for each aspect of metacognition studied in this study:

Table 3. N-gain score test results for each metacognitive skills component

Metacognitive Skills Component	***Pretest***	***Posttest***	***N-gain score***	**Category**
Planning skills	46.93	85.57	0.73	High
Monitoring skills	34.09	66.82	0.49	Medium
Evaluating skills	41.14	73.64	0.55	Medium

Table 3 above shows that planning skills, monitoring skills, and evaluation skills obtained N-gain scores of 0,73, 0,49, and 0,55 in the medium and high groups, respectively. The planning skill component obtained the highest N-gain score because students already understood the learning objectives and wrote down the known information from the problem (Danila & Agustina, 2021; Azizah & Nasrudin, 2021). Meanwhile, the monitoring skills component obtained the lowest N-gain score, this is because there are students who have not been able to determine strategies and consider them in solving problems (Mahmudah & Azizah, 2020). Students who have high metacognitive skills will also perform well in school (Danila & Agustina, 2021; Widyawati & Nasrudin, 2019). Overall, all components of metacognitive skills have improved by getting a medium or high category N-gain score.

After being tested with the N-gain score, the pretest and posttest data were compared to see if there was a significant difference between the two on each metacognitive ability component. A parametric test called the paired sample t-test is used to carry out a paired t-test. This is carried out because regularly distributed data must be present for parametric tests to be valid (Widana & Muliani, 2020). The SPSS 22 statistical package was used to perform the paired sample t-test. Table 4 below shows the outcomes of the paired sample t-test:

Table 4. Results of paired sample t-test test on each component of metacognitive skills

		Paired Differences					**T**	**Df**	**Sig. (2-tailed)**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
					Lower	**Upper**			
Pair 1	Pretest A - Posttest A	-38.63636	7.05958	1.50511	-41.76641	-35.50632	-25.670	21	.000

Pair 2	Pretest B - Posttest B	-32.72727	7.67297	1.63588	-36.12928	-29.32527	-20.006	21	.000
Pair 3	Pretest C - Posttest C	-32.50000	8.55653	1.82426	-36.29375	-28.70625	-17.815	21	.000

Description : A = Planning Skills, B = Monitoring Skills, C = Evaluating skills

Table 4 above, explains that each component of metacognitive skills obtained a sig value. (2-tailed) 0.000 <0,05 so that there is an effect of applying guided inquiry-oriented student worksheets to improve students' metacognitive skills on acid-base material. The metacognitive inventory questionnaire modified from Schraw and Dennison (1994) contains 10 positive questions and 10 negative questions covering three indicators of metacognitive skills that are trained, namely planning skills, monitoring skills, and evaluation skills. This questionnaire provides supporting information about students' metacognitive skills. The results of the average inventory questionnaire score on each component of metacognitive skills are presented in Figure 1 below:

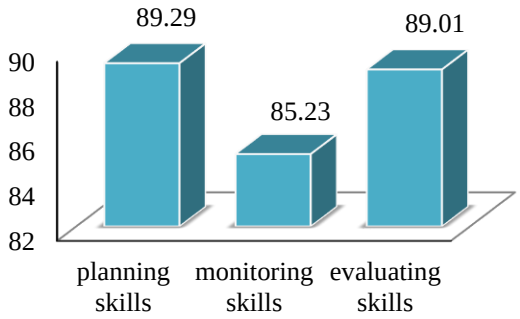

Figure 1. Diagram of average metacognitive inventory score on each component

Figure 1 above, shows that the highest metacognitive inventory score was obtained in the planning skills component and the lowest average was obtained in the monitoring skills component. Results from the inventory questionnaire ranged from≥85,23 to very good for each of the metacognitive abilities components. Based on these findings, it can be said that guided inquiry-oriented student worksheets have succeeded in improving students' metacognitive abilities related to acid-base material.

▪ CONCLUSION

Based on the results of the study, guided inquiry-oriented student worksheets to improve students' metacognitive abilities on acid-base material proved to be valid, very practical, and efficient. The average score of content and construct validity for student worksheets 1, 2, and 3 is 4,5-4,75, with valid or very valid categories. With a very practical category and supported by the results of observations of relevant student activities more often observed than irrelevant student activities, the practicality of student worksheets received a percentage of positive responses in the aspects of content, language, presentation, and graphics respectively of 94,05%, 100%, 87,87%, and 88,63%. The planning skills component of the effectiveness of student worksheets obtained an N-gain value of 0.73, the monitoring skills component of 0.49, and the

assessment skills component of 0.55 in the high or medium group. The effectiveness of the developed student worksheets is supported by metacognitive inventory scores of 89.29%, 85.23%, and 89.01% for the planning skills, monitoring skills, and evaluation skills components.

The purpose of this invention is to find ways to help students develop their metacognitive abilities. In addition, this research is also expected to contribute to improving education standards in Indonesia. As students' metacognitive skills improve, their learning outcomes will also improve. Future research is expected to look at more indicators of metacognitive skills. In addition, other studies are expected to focus on metacognitive knowledge as well as metacognitive skills.

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