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Development of an Assessment as Learning Based on an ISCACoRe Metacognitive Strategy to Improve Problem-Solving Skills

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Abstract: The purpose of this study is to develop an evaluation instrument for Dynamic Fluid materials with characteristics based on the ISCACoRe metacognitive strategy and determine the quality of the instrument to improve physics problem-solving skills. This study used research and development methods. The subjects of this developing study were 11th grade students at a senior high school in Yogyakarta. The ISCACoRe metacognitive strategy-based physics learning evaluation instrument was prepared in flip modules using the assessment-as-learning model, with characteristics of being independent, flexible, stimulating, and based on digital media. The instrument's validity is 86.25%, and the assessment as learning model's validity is 93.34%, indicating that the expert instrument is appropriate for use in learning evaluation activities. The level of an item's internal consistency is declared valid if $r_{xy} > 0.3961$, a total of 8 items are accepted because $r_{xy} > 0.3961$, and 2 items are rejected because $r_{xy} < 0.3961$. The Cronbach's alpha method of 0.817 and split-half of 0.875, with very high criteria, were used to obtain the results of the instrument reliability test. The experimental and control group obtained an average score of the normalized gain test (N-Gain) of 56.83%, and 44.10% respectively.

Keywords: Evaluation; Instrument; ISCACoRe; Metacognitive; Problem solving

Introduction

Learning is an activity that includes a series of processes for receiving knowledge, examining the meaning of that knowledge, and then applying the abilities that already exist in oneself so that it will produce a reflection of one's abilities through measurement, assessment, and evaluation. Heterogeneous individuals have diverse skills to become effective learners and thinkers, so they need the ability to self-regulate, especially in cognitive settings (Kozikoğlu, 2019). Cognitive abilities will be formed by the influence of several aspects, both within and outside of these students. Learners must practice controlling and managing their own learning processes and strategies (Modrek et al., 2018).

The level of student learning success can be identified through three methods, including measurement, assessment, and evaluation. Masidjo (1995) defines measurement as the activity of determining the quantity of an object through certain rules so that the quantity obtained truly represents the nature of the object in question. Evaluation is interpreted as a process of collecting data to determine where, what part, and how educational goals are achieved. Assessment is a process to determine the suitability of the process and results of an activity program with predetermined goals or criteria (Arikunto & Lia, 2009). Curriculum has conditional factors in its implementation and objectives to be achieved so that it can be reflected in its suitability in the learning process and assessment activities (Akbar, 2013).

Evaluation activities can be carried out at each stage of learning after a subject matter has been given to students. Assessment as learning is one of the learning evaluation models that not only measures student competence as the end result of learning activities based on a theory of knowledge but also helps students

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achieve an understanding of problem concepts for problem solving. Activities to evaluate student learning outcomes can be started by tracing the causes of students' difficulty with the material to find out their backgrounds and thought processes. One form of evaluation in learning is in the form of a test.

An Instruments of assessment as learning needs to be reviewed and analyzed for the benefits to support and improve the quality of learning. Analysis of the quality of the test instrument is a step that must be passed to determine the degree of quality of the test instrument for each item that is part of the test instrument or as a whole (Setiyawan & Wijayanti, 2020). The evaluation process has an important role in producing a product that is able to show indicators of competence that have been possessed by students. This is frequently an impediment in a learning evaluation activity, where learning outcomes cannot be represented as a whole, whether students understand the problem correctly, have no misconceptions, select strategies to solve problems, or analyze results to evaluate assessment results.

All of these activities can be stimulated by unlocking one's potential, one of which is metacognitive abilities, which will be reflected in cognitive ability results. Metacognition reflects a person's awareness of his own thought process through his ability to control that process (Ozsoy & Ataman, 2009). This ability can be optimized by spurring self-awareness and sharpening reasoning to understand problems, how to analyze problems, and then solve them. Metacognition becomes an effective element in problem-solving ability (Lester, 1994).

Metacognition is largely associated with efforts to optimize a person's ability in problem-solving efforts (Anggo, 2011) to optimize the learning outcomes and academic capabilities of students (Panaoura & Philippou, 2004). In principle, efforts involving metacognition in various learning activities are expected to improve the quality of the learning implemented (Muhali, 2014). Metacognitive awareness is defined as consciousness of thinking about what is known and what is unknown, meaning the student knows how to learn and the learning abilities they possess. Metacognitive knowledge is important for students because when they are able to monitor their learning process consciously, they will be more confident and independent in their learning (Hayatun et al., 2015) Students who have good metacognitive abilities will have good self-regulation, which will affect their learning outcomes (Norman & Furnes, 2016).

Metacognitive abilities can appear at an early age and will develop with age (Demetriou & Efklides, 1990). Students who have better metacognitive awareness are correlated with getting better learning outcomes as well (Hidayat & Sumarmo, 2013). Students will be trained to solve problems in all aspects of their lives as a result of their increased metacognitive awareness. Efforts to explore students' metacognitive abilities are one of the efforts to recognize potential characters in individual students. Educators must strive to understand the character of students and find solutions to improve the quality of their learning (Muhali, 2013).

The student's success in reaching a stage of learning results in him learning more optimally in reaching the next stage (Muisman, 2003). The concept of metacognitive methods can simplify complex contexts to be simpler to understand with understanding and deliberation so that learners can sort out unknown and unnecessary content (Yerushalmi & Magen, 2006). Problems structured with effective questions contribute to problem solving, trigger thinking processes, and stimulate the imagination to activate the metacognitive skills of learners (Hacker & Dunlosky, 2003). The study of operational problem solving, such as problem definition, practice, and outcome control, is not enough to learn what to do; one must also be able to implement and adjust strategies when they are used (McLoughlin & Hollingworth, 2001).

The primary factor underlying the failure of students in problem-solving is their inability to monitor their own minds during the problem-solving process (Artz & Armour-Thomas, 1992). Students should learn how to monitor and organize the steps and procedures used to solve problems. Academically performing learners acquire an understanding of themselves that supports effective strategies for problem-solving (Garrett et al., 2006). A metacognitive strategy will train students to understand that deficiencies in themselves are a stage of improvement; this process gives direct responsibility to students who are concerned about the process and optimal learning outcomes (Grotzer & Mittlefehldt, 2012). Based on the description, it is necessary to develop a learning evaluation instrument with a metacognitive strategy approach in an effort to improve the ability to solve physics problems.

Method

The method used in this study is research and development to develop and validate products used in education and learning (Borg & Gall, 1983). This study used the 3D model of define, design, and develop, which is a modification of the 4D model (Thiagarajan, 1974) as shown in Figure 1.

This study used the Purposive Sampling Control Group Pre-test and Post-test, with the experimental group treatment using a metacognitive strategy-based physics test instrument, while the control group used a

physics cognitive test instrument. Data collection was carried out using non-test instruments in the form of PMI and PSEQ questionnaires as well as test instruments for description types including initial tests (pre-test), treatment stage tests by giving cognitive questions based on ISCACoRe metacognitive strategies, and final tests (post-test). A series of instruments is arranged in this study in the form of an assessment as a learning model.

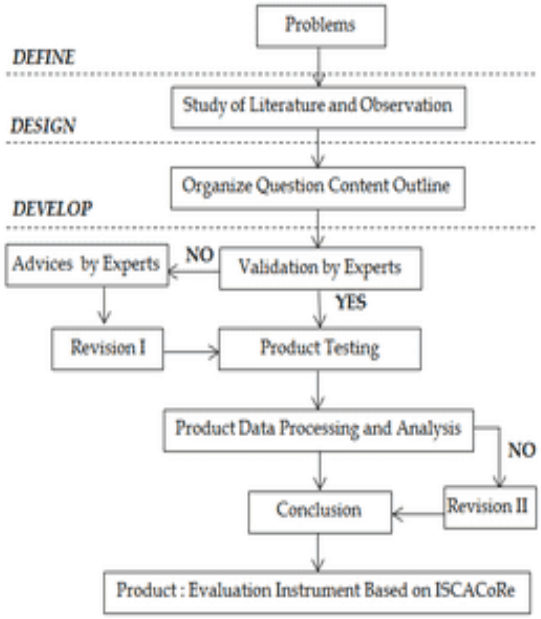

Figure 1. Schematic of research stages

This research was conducted in September 2022, at SMA N 1 Turi, Sleman, Yogyakarta. The test subjects for the product development research consisted of instrument experts and two classes of XI MIPA, including XI MIPA 1 as the experimental group and XI MIPA 2 as the control group, with 28 students in each group.

The pretest-posttest data of problem-solving skills were analyzed using the independent T-Test to obtain N-Gain to determine the improvement achieved by students. Analysis was carried out through item analysis and analysis of research data use IBM SPSS Statistics 26 software.

Result and Discussion

Research on the development of physics learning evaluation instruments based on the ISCACoRe metacognitive strategy is provided in the form of a flip module by the assessment as learning model.

Calibration of Test Instruments

Calibration of the test instrument is carried out to determine the feasibility or quality of the test instrument to be used. Instrument calibration includes the instrument validity, such as expert judgment and item validity, and the instrument reliability. Expert judgment aims to determine the validity of the test instrument to be used in research by consulting instrument experts (validators). Instrument validation by expert judgment was carried out to obtain the feasibility of the instrument through the instrument's expert advice before being used to collect research data. The results of expert validity based on the instrument item validity questionnaires are shown in Table 1.

Table 1. Instrument Validity by Experts

No.	Experts	Score (%)	Criteria
1	V-01	91.25	Very valid
2	V-02	88.75	Very valid
3	V-03	78.75	Valid
4	V-04	73.75	Valid
5	V-05	90.00	Very valid
6	V-06	82.50	Very valid
7	V-07	90.00	Very valid
8	V-08	83.75	Very valid
9	V-09	81.25	Very valid
Mean		84.44	Very valid

The mean item validity of the test instrument used to determine the problem-solving ability of Dynamic Fluid physics problems based on the ISCACoRe metacognitive strategy is 84.44%, which is very valid. These results indicate that the instrument is feasible to use for evaluation activities in physics learning, but improvements are still made according to the suggestions given by the validator and adjustments are made to the conditions in the field.

The results of the validity assessment as learning evaluation instrument module based on the ISCACoRe metacognitive strategy, which has been validated by experts, are presented in Table 2.

Table 2. Validity of the Assessment as Learning Model

No.	Experts	Score (%)	Criteria
1	V-01	97.78	Very valid
2	V-02	100.00	Very valid
3	V-04	80.00	Valid
4	V-05	88.89	Very Valid
5	V-06	80.00	Valid
6	V-07	86.67	Very valid
7	V-08	97.78	Very valid
8	V-09	97.78	Very valid
Mean		91.11	Very valid

The mean of the validity of the assessment as learning model used to determine the physics problem-solving ability of Dynamic Fluid materials based on the ISCACoRe metacognitive strategy is 91.11%, which is in the "very valid" category. The overall validation results show that there is a fairly good agreement between

experts because the statement items contained in each validation aspect are valid for assessing the entire ISCACoRe metacognitive strategy-based evaluation instrument.

Based on the results of expert validation of the instrument that has been declared feasible, the instrument can be utilized for additional study based on the determined results. A small-scale test is carried out on students who have studied material to obtain item internal consistency. In a small-scale trial, the items tested on students as Instrument Product I consisted of 10 descriptive questions with the concept of problem solving. Improvements were made on the advice of the experts for further small-scale testing. A product instrument called Instrument I, after the revisions are done, is tested on research subjects with a small-scale test, and then, after the revisions are made, it is used for a large-scale test as a product of Instrument II.

A small-scale trial was conducted with 25 students in class XII MIPA SMA N 1 Turi as respondents who had taken Dynamic Fluid material. The item's internal consistency in this study was carried out by statistical analysis, assisted by *the IBM SPSS 26 software application*. The item's internal consistency in small-scale trials is presented in Table 3.

Table 3. Item Internal Consistency

No.	r_{xy}	Criteria	Interpretation
1	0.652	High	Item accepted
2	0.744	High	Item accepted
3	0.181	Low	Item rejected
4	0.690	High	Item accepted
5	0.613	High	Item accepted
6	0.200	Low	Item rejected
7	0.603	High	Item accepted
8	0.640	High	Item accepted
9	0.671	High	Item accepted
10	0.703	High	Item accepted

The item's internal consistency was tested using the product in a small-scale test, as presented in Table 3. The respondents involved were 25 students, so for N = 25, with a significance level of 5%, an estimate r_{table} of 0.3961 was obtained. Because the level of an item's internal consistency is declared valid if r_{xy} > 0.3961, a total of 8 questions are included in the high criteria, and items are accepted because r_{xy} > 0.3961, and 2 items are included in the low criteria, and items are rejected because r_{xy} < 0.3961.

Two items that are rejected have a low category and are not used in the preparation of Instrument II products, and an item has a high category but is not used properly because it is adapted to field conditions. Thus, it can be said that the items of the physics learning evaluation instrument based on the ISCACoRe metacognitive strategy deserve to be given to students in a large-scale test to determine students' problem-solving abilities in Dynamic Fluid material.

Instrument Reliability Test

An instrument can be declared reliable if it gives consistent results even after it has been used to take measurements many times. The reliability value was obtained based on the results of the test on the material's Dynamic Fluid description in a small-scale test with a valid category of eight description questions. A small-scale test was conducted with 25 students from class XII MIPA SMA N 1 Turi. The reliability test in this study was carried out by statistical analysis using the *Cronbach's alpha* test, assisted by the *IBM SPSS Statistics 26* and Anates V4 software applications. The reliability of the instrument obtained from the small-scale test is presented in Table 4.

Table 4. Reliability of Test Instruments

r_{table}	Min. Cronbach Alpha	r_{xy} (Cronbach Alpha)	r_{xy} (Split- Half)	Criteria
0.3961	0.600	0.817	0.875	Very high

Based on information from the data presented in Table 4, the reliability of the instrument in a small-scale test involving 25 respondents indicated that N = 25 with a significance level of 5% had an r_table value of 0.3961. The results of the instrument reliability test on a small-scale test using *IBM SPSS Statistics 26 software* were obtained by the *Cronbach alpha* method of 0.817 and *Split-half* of 0.875 with very high criteria. *A Cronbach Alpha* of 0.600 is considered a good reliability value. This indicates that the instrument items in this study are declared reliable for further large-scale testing.

Normality Test

The normality test was carried out on the pre-test results of 56 students of class XI MIPA SMA N 1 Turi, consisting of 28 students of class XI MIPA 1 as the experimental class and 28 students of class XI MIPA 2 as the control class. The test at this stage is to determine the problem-solving ability, which aims to clarify the distribution of the data for the two variables that are normally distributed or not. The normality test in this study was carried out using pre-test data with statistical analysis using the Kolmogorov-Smirnov test.

The data distribution is declared normally distributed if it has a probability value of Sig. > 0.05, and vice versa, the data distribution is declared not normally distributed if it has a probability value of Sig. 0.05. The normality test are shown in Table 5.

Based on the information presented in Table 5, the results of the pre-test data normality test in the experimental group using *the* IBM SPSS Statistics 26 software application with the Kolmogorov-Smirnov test gave a probability value of Sig. 0.200 and a probability value of Sig. 0.126. This shows that the significance of the group data is normally distributed. The distribution of group data used in this study is in accordance with the requirements for normally distributed data, which has a probability value of Sig. > 0.05. The experimental and control group can be used to collect research data with a large-scale test based on the results of the normally distributed data. Based on the results, the groups have been normal and could be used to get research data.

Table 5. The Result of the Data Normality Test

Pre-Test Group	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Experiment	.126	28	.200*
Control	.147	28	.126

Independent T-Test

The independent T-test was carried out in this stud y as a parametric statistical test that aims to test the significance and relevance of post-test data. The results of the independent T-test on the post-test results of the two groups, with respondents consisting of 28 students in the experimental group and 28 students in the control group, are presented in Table 6.

Table 6. T-Test Results

	Levene's Test for Equality of Variances	t-test for Equality of Means	
	Sig.	df	Sig. (2-tailed)
Equal variances assumed	.467	54	.000
Equal variances not assumed		53.117	.000

Based on Table 6, the results of the independent T-test in this study obtained the probability value of sig. Levene's Test for Equality of Variances of 0.467, which indicates that the data variance in each group of the experimental group and control group is homogeneous, or the same. The probability value of sig. > 0.05 states that Ho is accepted and Ha is rejected, so that the data is declared to be normally distributed and homogeneous. Table 6 shows that sig. The t-test for Equality of Means is 0.000 < 0.05, so the decision in the independent T-test is Ha is accepted and Ho is rejected. Thus, it can be concluded that there is a significant difference between the average post-test results in the experimental group after treatment assessment based on learning based on the ISCACoRe metacognitive strategy and the control group without treatment after testing the ISCACoRe metacognitive strategy-based evaluation instrument was carried out.

Normalized Gain Test (N-Gain)

The analysis of the N-Gain test was carried out by the IBM SPS Statistics 26 software application. The N-Gain test results are shown in Table 7.

Table 7. Normalized Gain Test (N-Gain)

	N-Gain Score (%)	
	Experiment Group	Control Group
Minimal Score	21	21
Maximal Score	83	78
Std. Deviation	15.36	12.57
Mean	56.83	44.10

Based on the information presented in Table 7, it shows that the test in the experimental group obtained an average score of the normalized gain test (N-Gain) of 56.83 percent, and the control group obtained an average score of the normalized gain test (N-Gain) of 44.10%. This value is declared quite effective and shows that the treatment given as treatment in the experimental group by providing an assessment as a learning model using an evaluation instrument based on the ISCACoRe metacognitive strategy with Dynamic Fluid material description questions can be applied in the evaluation process. Thus, a comparison can be made to show that the treatment given in this study is significant enough to improve the ability of students to carry out the physics problem-solving process.

Problem-Solving Analysis

The control group without treatment in this study showed an increase in academic results, but after analysis, it was found to be less effective. The problems faced by students will provide experience in the process of finding solutions (Negoro et al., 2020; Rusilowati et al., 2016). The process of finding a solution will result in a change in the construction of thinking; even without any treatment, it will make a slight change in the results that can be measured, especially in academic assessments (Putra et al., 2022).

In this study, the treatment used aims to stimulate understanding of the concept of the problem presented in the problem and then provide stages of completion with the help of scaffolding in the form of questions that explore students' metacognitive awareness. A question item with the question scaffolding used in the treatment is shown in Figure 2.

Figure 2 shows the items used in the treatment of Dynamic Fluid material with question scaffolding given as stimulation and assistance that aims to explore metacognition and self-awareness to find out what steps

must be taken to find strategies for solving problems so that results are obtained as the final answer. The next stage is a posttest with problem-solving items to measure the effectiveness of treatment. The results of solving problems by S25 in the pretest are shown in Figure 3, the results of solving problems by S25 in the posttest are shown in Figure 4, and the conclusion and self-explanation by S25 are shown in Figure 5.

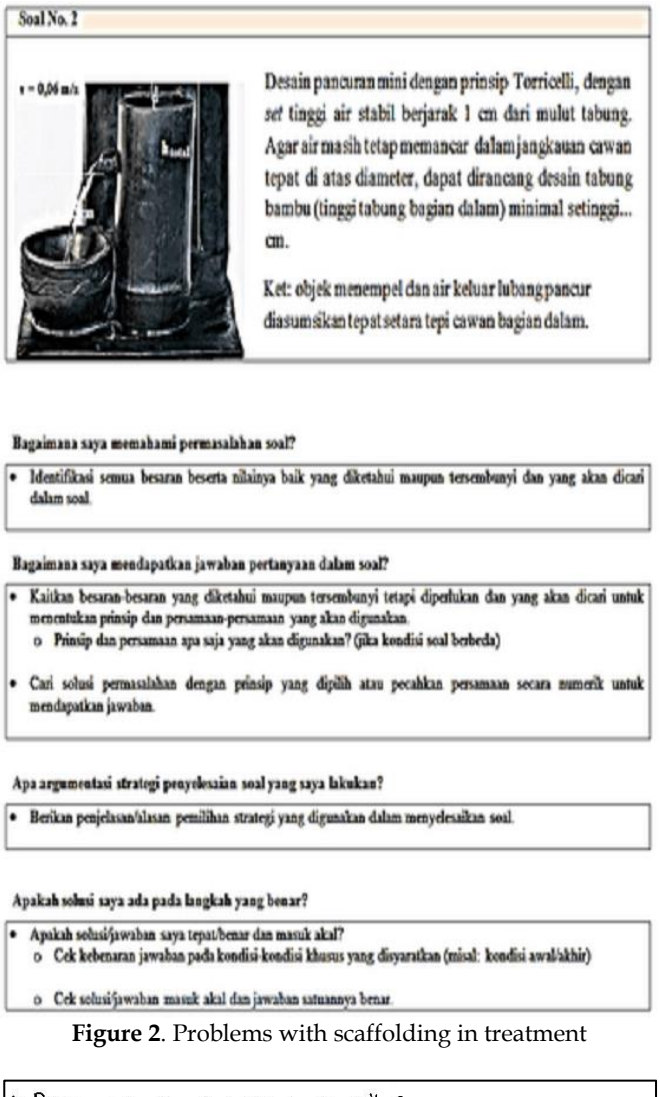

Figure 2. Problems with scaffolding in treatment

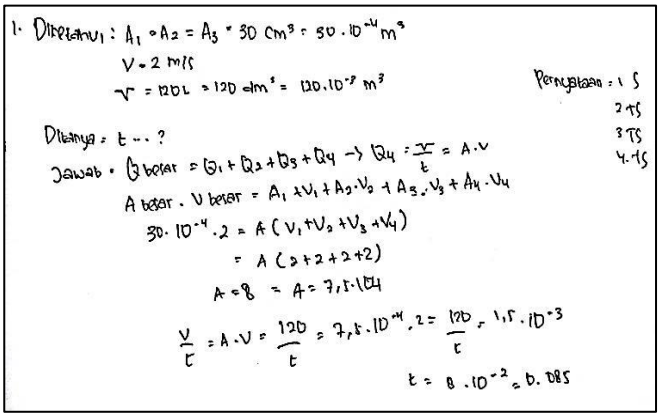

Figure 3. The solution of the pretest by S25

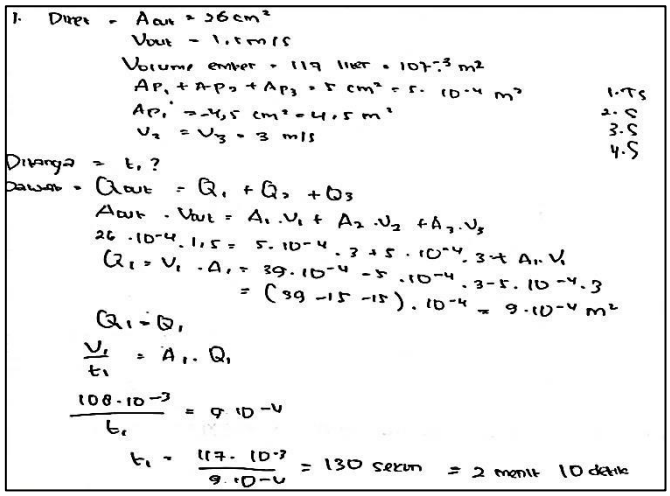

Figure 4. The solution of the posttest by S25

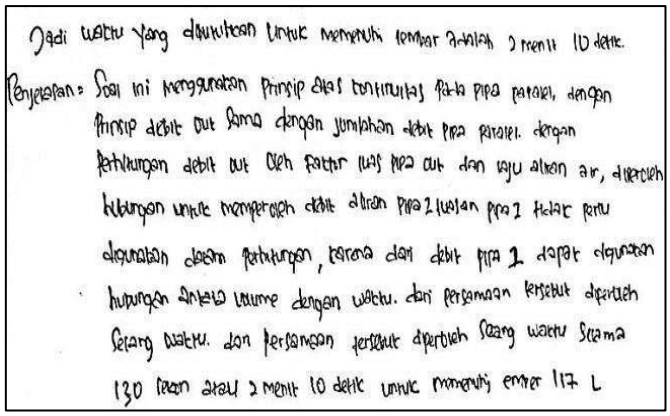

Figure 5. The conclusion and self-explanation by S25

Based on the results of the problem-solving ability of one of the students as S25, the value of metacognitive awareness was obtained on the PMI questionnaire before treatment at 65.38 and increased after treatment to 66.92. The outcomes of self-efficacy ability in the PSEQ of S25 also increased from 78 to 80. This had a positive impact on the problem-solving ability of S25 when given physics problems. The results of the problem-solving ability of S25 increased from 66 to 73. Then a comparison was made to see if S25's ability to solve problems had improved.

Based on Figure 3, it is shown that S25 solves the problem presented with the correct formula according to the continuity principle and the concept of discharge in parallel pipes. It can be seen that S25 understands the problem and knows the strategy by choosing the right formula, but his mathematical operations still make mistakes. It is assumed that S25 has not correctly understood the answers expected by the questions and has not evaluated whether the answering strategy is correct and in accordance with the expected questions.

Based on Figure 4, it is shown that the posttest results after S25 received treatment had a different pattern in answering the questions. On these results, S25

answered in a more structured manner because he had experience gained during treatment. The answers are arranged completely and precisely according to the physical concept presented in the problem, but There is a typo in the nominal when entering the quantity in the formula, even though the known amount is correct. Due to the lack of accuracy, the calculation is still done correctly. Based on self-awareness statements, S25 experienced an increase in self-confidence, as seen from the results of the statement item answers from the pretest stage, with 3 items disagreeing (TS) and 1 item agreeing (S). These results increased at the posttest stage, namely, S25 self-confidence increased with 1 item disagreeing (TS) and 3 agreeing items (S).

S25 was able to correctly conclude answers based on questions and evaluate them, as shown in Figure 5. In the final answer, S25 did a self-explanation, as shown in Figure 5, by giving an explanation of the answers that had been done, sequentially from understanding the concepts presented, the answering strategy, the chosen formula, and the sequence of steps to work on to get results with the right mathematical operations to get the right results. The results of the analysis of the increasing problem-solving ability test results were obtained in the fairly effective category.

Conclusion

The ISCACoRe metacognitive strategy-based physics learning evaluation instrument is arranged in flip modules using the assessment-as-learning model, with characteristics of being independent, flexible, stimulating, and based on digital media. The expert instrument's validity is 86.25%, and the model assessment as learning's validity is 93.34%, indicating that the expert instrument is appropriate for use in learning evaluation activities.The Cronbach's alpha method of 0.817 and split-half of 0.875 with very high criteria were used to obtain the results of the instrument reliability test.The test in the experimental group obtained an average score of the normalized gain test (N-Gain) of 56.83%, and the control group obtained an average score of the normalized gain test (N-Gain) of 44.10%. In general, the ISCACoRe metacognitive strategy-based treatment has a significant impact on the process of solving physics problems faced by students.

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Author Contributions
The authors contribution to the paper is as follows: study conception and design: author 1, data collection: author 1, analysis and interpretation of results: authors 1, 2, and 3; draft manuscript preparation: 1, 2, and 3 authors; all authors reviewed the results and approved the final version of the manuscript. The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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Conflicts of Interest
No conflicts of interest.

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