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Improving Metacognitive Ability and Learning Outcomes with Problem-Based Revised Bloom's Taxonomy Oriented Learning Activities

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Abstract

This study aims to analyze the impact of Bloom's revised taxonomy-oriented learning activities with problem-based learning models on students' metacognitive skills and learning outcomes. A quasi-experimental design is used as the research method, and the quasi-experimental design is implemented as a pure post-test-control design. All fourth-year students participated in the study, with a total of 132 students participating. The sample was randomly selected and corresponded to 84 students. A 10-question test was used to collect the data. MANOVA with SPSS support was used as the analytical method. The significance of the test results was < 0.00. According to the results, 0.05. This means that learning that uses a combination of problem-based learning models and learning activities aligned with the revised Bloom taxonomy can influence students' metacognitive skills and learning outcomes. Students are at the central of their learning, so they are actively involved in the learning process. This learning activity develops students' metacognitive skills and provides an opportunity to reflect on what they know about themselves and to be honest and confident in their knowledge. Additionally, learning activities are organized by learning objectives to help students improve their learning outcomes.

Keywords:

Learning Activities;
Bloom Taxonomy;
Metacognitive;
Self-Assessment;
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1- Introduction

One of the characteristics of successful learning is good interaction between students and teachers, students and other students, and students and learning resources. A good learning process encourages students to discover and investigate their own knowledge. Providing opportunities for students to discover and explore their own knowledge provides meaningful experiences and influences their social and emotional development [1, 2]. A meaningful learning experience enables students to apply what they learn in the classroom to their daily lives. The learning process is currently under scrutiny and needs to move from face-to-face learning to online learning. Online learning was chosen as COVID-19 is currently affecting Indonesia and the rest of the world. Online learning is learning that takes place both synchronously and asynchronously via the internet and allows students to interact with learning resources more flexibly, both within the educator environment and with their peers [3–6]. To realize conducive online learning, students and educators must be technologically savvy [7, 8]. Online learning allows for a seamless learning process. In addition, students can continue to improve their thinking skills. One of the thinking skills that must be possessed by students is metacognition ability. Metacognition is an important thinking ability that must be mastered by students.

Students need metacognitive abilities to recognize when they make mistakes and to evaluate their work. Not only that, but students are expected to assess which strategies are effective and which are less effective. Children's

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metacognition is always related to learning, remembering, and academic activities [9]. Metacognitive is defined as the ability to reflect, understand, and control learning [10, 11]. The existence of metacognitive experience will give students insight into knowledge [12]. Basic metacognitive abilities affect children's memory performance for more future development of children [13]. Metacognition influences information perception and processing in ways that influence students in improving learning outcomes [14, 15]. Metacognition is very important for every student to develop independence in learning [16]. Good metacognition will make students able to solve problems well [10]. Based on this explanation, when students' metacognition is good, their learning outcomes are also good. The role of the teacher in learning design is critical for achieving good learning outcomes.

The facts that occur in the field show that the learning activities implemented by the teacher have not been able to involve students optimally. The majority of teacher-centered learning causes a lack of student participation in the learning process [17, 18]. Teachers provide more theoretical explanations than students do in their activities. This has an impact on the low metacognitive ability of students. Student activities in learning are only limited to listening to teacher explanations, doing assignments, and conducting discussions, so there are no more activities carried out by students to support learning. Students tend to be passive in every aspect of the teaching and learning process and show less passion, interest, and enthusiasm for learning [17]. Problems in learning arise because students rarely respond to the teacher's questions during the lesson and lack of attention when the teacher explains the components and learning activities. Student activities are only limited to seeing, listening, and recording, so many students play, sleep, or sit quietly in class during the learning process [17, 19]. Students with low metacognitive skills may be unable to monitor themselves or understand learning objectives. Students never plan the time that will be used to complete the tasks given by the teacher, so that they feel they are short on time. In addition, this low metacognitive ability is characterized by a lack of using previous knowledge, organizing the information obtained, knowing how and when to apply strategies, managing the effectiveness of the learning strategies used, and applying what has been learned. On the other hand, students do not develop their ability in the thought process when solving the given problem. As a result, when students are faced with a difficult task that requires critical thinking skills or the answer is not immediately obtained, they tend to be lazy to do it.

The solution that can be used to overcome the low metacognitive ability of students is to apply innovative learning. Several previous studies have shown that the application of innovative learning can develop students' metacognitive abilities. Throughout the innovative learning process, students are expected to achieve excellent learning outcomes. In practice, however, the learning outcomes achieved by students are poor and do not meet expectations. Lack of attention to teachers when teaching, both male and female students. Teachers do not use learning methods that attract students' attention, so students are easily bored with learning [18]. By default, whether the learning outcomes are in accordance with the KKM, which is set as a measure of the success of the learning process. There must be interest and evaluation materials in the learning process. Student learning outcomes demonstrate a student's competence and quality as a result of the learning process that the student has taken through [20]. Of course, if this issue is not addressed, the learning process and outcomes will suffer. Using these problems to motivate students and provide opportunities for them to improve their metacognitive skills and learning outcomes is an essential part of problem-based learning combined with Bloom's revised taxonomy-oriented learning activities. It is possible to achieve this through development. With PBL, the gap between critical thinking and students' strengths in the learning process can be bridged [21]. PBL improves student performance while they are learning [22]. The PBL model promotes social constructivist principles, transforming the learning experience into a gold mine of lifelong learning opportunities [23]. Online problem-solving training improves student performance, problem-solving skills, and classroom interactions [24]. Furthermore, PBL provides students with opportunities to practice critical thinking skills in a variety of contexts [25]. Using PBL models in the classroom assists students in developing critical thinking skills, improving learning outcomes, and increasing student activity. This positive impact is the impetus for this research.

Problem-based learning is combined with a revised Bloom taxonomy-focused learning activity in this study. Students benefit from learning activities because they can actively participate in learning. The achievement of effective learning activities is undeniably dependent on planning, so Bloom's taxonomy can assist you in achieving your learning objectives optimally. A taxonomy is a framework that supports teachers in categorizing statements that are used to predict a student's learning ability as a result of a learning activity [10, 26]. A learning overhaul can have a significant impact on increasing student knowledge with increasing student learning outcomes, particularly on students' metacognitive knowledge, according to Bloom's taxonomy. Learning activities that focus on Bloom's taxonomy are redesigned to improve metacognitive abilities while also producing innovative and diverse learning outcomes. Students' learning activities, which are motivated by a desire to learn, demonstrate that they already have the confidence to study seriously. We can see children who are highly motivated to learn and who perform well in learning activities [27]. One of Bloom's revised taxonomy-oriented learning activities that is carried out is self-awareness about work. 1) Self-awareness of accepting diversity; 2) self-awareness of making collages and mosaics as part of his art. The faculty first evaluated the effectiveness of the learning activities based on Bloom's taxonomy for the students. This study aims to analyze the impact of Bloom's revised taxonomy-oriented learning activities with problem-based learning models on students' metacognitive skills and learning outcomes. The results of this study are expected to contribute to the implementation of innovative learning processes to improve students' metacognitive abilities.

2- Methodology

This study is quasi-experimental in nature with a pretest-protest-control group design. A problem-based learning model and Bloom's taxonomy guided learning activities for the experimental group. Throughout the research, Bloom's taxonomy was revised. The control group, on the other hand, was given a problem-based learning model that did not include any of Bloom's revised taxonomy-oriented learning activities. Both experimental and control groups underwent pre-testing to determine baseline conditions before treatment, followed by post-testing to determine differences in metacognitive skills and learning outcomes between experimental and control groups. The flow of this research design is presented in Figure 1. This study included all fourth graders from Gugus VII Kecamatan Sukasada, a total of 132 students from six schools. ANOVA was used to perform a population equivalence test, which revealed that all classes were equal. A random sampling method was used to collect samples. The experimental and control classes were then determined using random sampling. SDN 1 Selat used to have 25 experimental classes, while SDN 3 Selat had 20. SDN 4 Selat has 19 students, and SDN 2 Selat has 20 students as control classes.

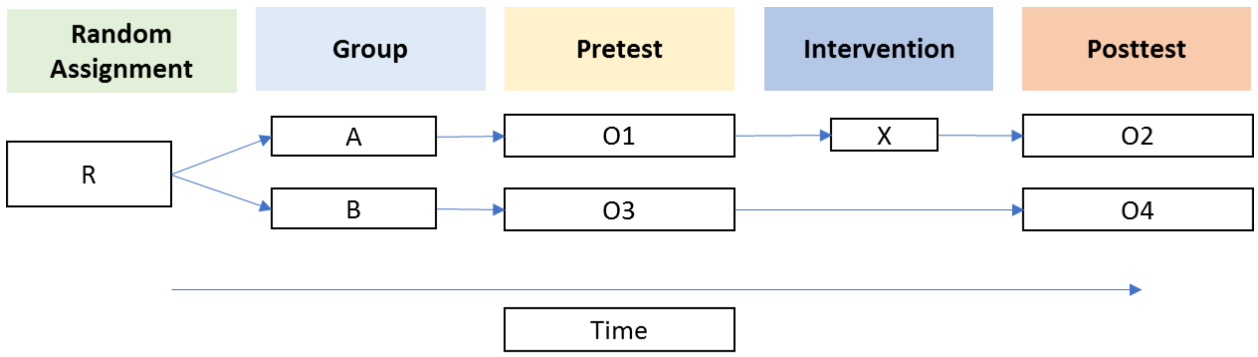

Figure 1. **Research Design**

Data collection for this study was performed according to the test method. Twelve essay questions and descriptive tests were used as a means of metacognitive performance testing. It is made according to the recognition level of 4th graders. The questions consisted of 2 C1 questions, 1 C2 question, 2 C3 questions, 3 C4 questions, 2 C5 questions, and 2 C6 questions. Before using the metacognitive ability tester, it was validated, reliable, and difficult. CVR is used for content verification. CVR testing found all elements of the manufactured metacognitive ability testing device to be effective and usable. The metacognitive ability test device created a CVR of 11.5. This shows that there are various approaches to the CVI calculation once the CVR results are known. With very good prerequisites, his CVI on the metacognitive performance test instrument was 0.9. For the high reliability criterion, reliability calculations yielded 0.75. The difficulty level of the metacognitive ability test items was intermediate (8 out of 10) and easy (2 out of 10). The explanatory test kit had a difficulty rating of 0.69, so it met the moderate criteria. A grid of the metacognitive ability test equipment shown in Table 1.

Table 1. **Metacognitive Ability Test Instruments**

Basic competencies	Number of Questions	Description
3.2 Determine the relationship between social, economic, cultural, ethnic, and religious diversity in local provinces and Indonesian national identity.	2	Valid
3.3 Differentiate between muscle, electrical, magnetic, gravitational, and frictional forces.	2	Valid
4.3 Demonstrate the advantages of force in everyday life, including muscular, electrical, magnetic, gravitational, and frictional forces.	2	Valid
1.4 Thank you for the many forms of ethnic, social, and cultural diversity in Indonesia that are united by unity and integrity as a gift from Almighty God.	2	Valid
3.4 Understand the adhesion technology.	2	Valid
4.4 Can make collages, montages, apps, and mosaics.	2	Valid

As a means of testing learning outcomes, a descriptive test consisting of ten essays. The items created were tailored to fourth graders' cognitive abilities. There were two C1 questions, two C2 questions, two C3 questions, two C4 questions, one C5 question, and one C6 question. Validate any learning outcome test instrument before using it. CVR is used for content verification. For learning outcomes, his CVR test instrument score is 12. The analysis then moves on to the CVI calculation once the CVR results are known. They performed admirably on the learning outcomes test, with a CVI of 1. Table 2 contains a grid of learning outcome test instruments.

Table 2. Learning Outcome Test Instruments

Basic competencies	Cognitive Realm	Number of Questions	Description
3.2 Determine the relationship between social, economic, cultural, ethnic, and religious diversity in local provinces and Indonesian national identity.	C1	2	Valid
3.3 Differentiate between muscle, electrical, magnetic, gravitational, and frictional forces.	C5	1	Valid
4.3 Demonstrate the advantages of force in everyday life, including muscular, electrical, magnetic, gravitational, and frictional forces.	C2	2	Valid
1.4 Thank you for the many forms of ethnic, social, and cultural diversity in Indonesia that are united by unity and integrity as a gift from Almighty God.	C3	2	Valid
3.4 Understand the adhesion technology.	C4	2	Valid
4.4 Can make collages, montages, apps, and mosaics.	C6	1	Valid

Data from the post-test were analyzed using descriptive and inferential statistics. The effectiveness of developing learning activities in accordance with Bloom's revised taxonomy on students' metacognitive skills and academic outcomes was determined using inference statistical analyses. The MANOVA test was used in statistical inference analysis. Prior to running the MANOVA test, the following prerequisite tests were run: normality, homogeneity, and multiple correlations. SPSS 25.0 for Windows was used to run MANOVA and prerequisite tests.

3- Results and Discussion

3-1- Results

The purpose of this study was to examine the impact of Bloom's problem-based learning model combined with revised taxonomy-oriented learning activities on student metacognitive skills and learning outcomes. Table 3 summarizes the descriptive analysis findings.

Table 3. Results of Descriptive Analysis of Metacognitive Ability and Learning Outcomes

Descriptive Statistics					
Treatment		Dependent variable	Mean	Std. Deviation	N
A1 (Experiment)	Pre-test	Y_1	51.5294	7.94006	36
		Y_2	48.8824	7.51872	34
	Post-test	Y_1	78.0556	9.22712	36
		Y_2	75.5000	8.00536	34
A2 (Control)	Pre-test	Y_1	49.9094	6.94006	36
		Y_2	45.6524	6.51872	34
	Post-test	Y_1	62.5714	15.46250	36
		Y_2	60.1714	13.86352	34

The next test carried out was the prerequisite test for the pretest data group for both Metacognitive Ability data and student learning outcomes. The normality test results using the Kolmogorov Smirnov statistic obtained the results of the pretest data, both metacognitive ability data and student learning outcomes that were normally distributed (Sig. > 0.05) with a score of 0.1046 for Metacognitive Ability and 0.084 for the result score. The homogeneity test is the second prerequisite test performed. The homogeneity test of metacognitive ability data and learning outcomes yields results from homogeneous data groups. It is denoted by (Sig. > 0.05), which for metacognitive ability is 0.253 and for student learning outcomes is 0.743. Based on the prerequisite test, both metacognitive abilities and learning outcomes come from a normal and homogeneous distribution so that the independent t-test can be continued. The results of the t-test showed (sig.>0.05) with a score of 0.455 for metacognitive ability and 0.653 for student learning outcomes. This indicates that both experimental and control groups did not differ based on sig. > 0.05Analytical prerequisite tests performed included data distribution normality, variance homogeneity, multivariate homogeneity, and dependent variable linearity. The analysis results show that all data are from normally distributed data groups. sig. > 0.05 can indicate this. The Kolmogorov-Smirnov normality test was the first prerequisite test. Table 4 displays the normality test results.

Table 4. Normality Analysis Results

Learning approaches		Kolmogorov-Smirnov		
		Statistic	df	Sig.
Metacognitive Ability	PBL model combined with revised Bloom's taxonomy-oriented learning activities	0.083	36	0.200
	PBL model without implementing revised Bloom's taxonomy-oriented learning activities	0.112	34	0.200
Learning outcomes	PBL model combined with revised Bloom's taxonomy-oriented learning activities	0.115	36	0.200
	PBL model without implementing revised Bloom's taxonomy-oriented learning activities	0.104	34	0.200

After the normality requirement is satisfied, the next prerequisite test is the homogeneity test. In this study, he used his two analyzes to test for homogeneity. It is a multivariate homogeneity test. Homogeneity analysis results show the same validity. This indicates that the study data were obtained from a homogeneous data set. This is supported by the sig value. Each test emits a signal. A value greater than or equal to 0.05. For metacognitive skills, the Levene Equality Test is 0.285 and the Sig. Learning Outcome score is 0.672. In contrast, the homogeneity test using the box covariance matrix gave a signal of 0.671. The linearity test, which attempts to determine the linear relationship between the analyzed dependent variables, is the next prerequisite test. The analysis revealed a 0.032 sign-on deviation from linearity (0.05). This means that metacognitive performance data and learning outcomes have no direct relationship. The necessary tests for MANOVA analysis have been completed. Manova can be used to test your hypothesis because the resulting study data are normally distributed and uniform, with no linear relationship between the variables. Table 5 presents the findings of the overall analysis.

Table 5. Results of the Manova Test Analysis

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	0.985	2233.707	2.000	67.000	0.00	0.985
	Wilks' Lambda	0.015	2233.707	2.000	67.000	0.00	0.985
	Hotelling's Trace	66.678	2233.707	2.000	67.000	0.00	0.985
	Roy's Largest Root	66.678	2233.707	2.000	67.000	0.00	0.985
Group	Pillai's Trace	0.751	101.074	2.000	67.000	0.00	0.751
	Wilks' Lambda	0.249	101.074	2.000	67.000	0.00	0.751
	Hotelling's Trace	3.017	101.074	2.000	67.000	0.00	0.751
	Roy's Largest Root	3.017	101.074	2.000	67.000	0.00	0.751

According to the MANOVA results in Table 5, the Pillae trace, Wilks' Lambda-Hotelling trace, and Roy's largest root indicate an F-factor of 101.074 for Sig. 0.00. This means that metacognitive skills and learning outcomes differ across groups of students participating in learning activities.

Table 6 shows the results of the inter-subject efficacy test analysis, which showed an F-score of 165,333 with a sig. of 0.00 less than 0.05. We showed that problem-based learning combined with Bloom's modified taxonomy-oriented learning activity improved students' metacognitive abilities. Third, the F-score for the influence test between subjects is 205.043, sig. 0.00, less than 0.05. Making learning activities the effectiveness of student learning outcomes can be demonstrated by using bloom's revised taxonomy.

Table 6. Analysis results of Tests of Between-Subjects Effects

Tests of Between-Subjects Effects							
Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Metacognitive Ability	12303.583	1	12303.583	165.333	0.000	0.709
	Learning outcomes	12388.613	1	12388.613	205.043	0.000	0.751
Intercept	Metacognitive Ability	293624.726	1	293624.726	3945.665	0.000	0.983
	Learning outcomes	270520.956	1	270520.956	4477.375	0.000	0.985
Group	Metacognitive Ability	12303.583	1	12303.583	165.333	0.000	0.709
	Learning outcomes	12388.613	1	12388.613	205.043	0.000	0.751
Error	Metacognitive Ability	5060.359	68	74.417			
	Learning outcomes	4108.529	68	60.420			
Total	Metacognitive Ability	314676.000	70				
	Learning outcomes	290560.000	70				
Corrected Total	Metacognitive Ability	17363.943	69				
	Learning outcomes	16497.143	69				

3-2- Discussion

We have some insights based on our research findings. For starters, there is a link between students' metacognitive abilities and classroom learning outcomes taught using a combination of problem-based learning and Bloom's revised taxonomy. It is inextricably linked to the activities that the learning process engages the student in the learning process. Active learning should maximize each student's potential so that they can achieve satisfactory learning outcomes based on their characteristics. Furthermore, active learning helps students maintain their focus on the learning process [28]. As a result, even though the student accepts the knowledge provided by the teacher, the learning process necessitates active participation on the part of students. Teachers should use learning activities that are appropriate for elementary school students' characteristics, and they should emphasize student activities by assessing and analyzing what they have learned [29, 30]. Good learning processes can engage students in important roles in teaching and learning activities [31]. Motivation to learn drives students to engage in learning activities, which indicates that students already have the confidence to study seriously. A child who is highly motivated to learn and who is good at learning activities is one thing to see in action [32]. When concrete objects are used, students are more motivated to engage in hands-on learning. As a result, students become more interested, engaged, and deeply understand their learning. Students in elementary school are theoretically in a concrete working stage, and when supported by concrete objects, children begin to use their minds to think rationally and objectively [33]. There is a relationship between metacognitive skills and learning outcomes, and students with good metacognitive skills have better learning outcomes. Students with metacognitive skills can analyze and evaluate problems that arise during the learning process. Children's metacognition is always linked to their learning, memory, and academic activities [9]. Metacognitive is defined as the ability to reflect, understand, and control learning [10]. The existence of metacognitive experience will give students insight into knowledge [12]. Basic metacognitive abilities affect children's memory performance for more future development of children. Metacognition affects a person in absorbing and processing information so that it will affect students in improving learning outcomes [14, 15]. Metacognition is very important for every student to develop independence in learning [16]. Good metacognition will make students able to solve problems well [34]. So, if the child's metacognitive ability is good, the learning outcomes obtained by students are even better.

The second finding is differences in students' metacognitive abilities taught by combining the problem-based learning model with Bloom revision taxonomy-oriented activities. The difference in students' metacognitive abilities cannot be separated from the learning carried out, where students who take part in this learning will be trained to complete the activities that have been provided. Problem-based activities found in everyday life will provide opportunities for students to manage their knowledge well. Student learning activities motivated by learning motivation indicate that students are already aware of the importance of studying seriously [35]. Through learning activities oriented to Bloom's revised taxonomy, students are given an active opportunity to develop their metacognitive abilities. In this learning activity, concrete learning materials are used, using visual tools and collaborating with games, using examples already familiar to students ranging from simple to complex, providing real practice in analyzing problems or activities. Through this learning activity, students become accustomed to reflecting on what they know and do not know, allowing them to be consciously honest about what they know and correct their mistakes. Students with metacognitive skills can gain a thorough understanding of problems and their solutions, bolstering their confidence in learning and problem solving by employing logical arguments [36]. A student's metacognitive skills are very helpful in their learning success. Consider what you think about the students' ability to come up with different ways to solve problems. So, learning activities will affect students' metacognitive abilities in the learning process.

Our third finding indicates that combining problem-based learning models with Bloom's taxonomy-based operations has a significant impact on improving learning outcomes. Fourth graders practice one of the goals of the school learning process, which is student achievement. To do so, teachers must be familiar with, learn, and apply a variety of teaching methods. Teachers must educate and teach students using learning methods that are necessary for the learning process in the classroom to achieve high student performance (outcomes) [37]. Bloom's revamped taxonomy-focused learning activities increase student engagement in learning. Students actively participate in learning, including by asking questions about the material being taught. Learning activities based on active learning are the processes by which students maximize their potential to engage in more learning activities, establish interactive relationships with the subject matter, and achieve good learning outcomes [38]. Learning activities based on Bloom's revised taxonomy have shifted learning from the teacher to the student as the active center of learning. Learning that is good allows students to explore and build knowledge. Students gain experience that they can apply in their daily lives by learning in this manner. Meaningful learning provides students with experiences and opportunities to develop social feelings [1, 2]. In addition to activity-filled learning with problem-based learning constructs, students are more actively involved in the learning process. Students will also collaborate with their peers. Students learn more effectively when they collaborate with their peers. Learning with peers encourages students to participate actively in their education [39]. The peer method enhances self-learning. Students have received peer feedback. The peer method improves self-learning. Students have experience with peer feedback [40]. Peers guide and support one another as they learn through interaction and collaboration [41]. Anxiety and stress are reduced when students learn with their peers. Students gain confidence through peer mentoring, support, and feedback [42, 43]. Based on these descriptions, learning should enable students to share learning expectations to create a conducive learning environment and to follow the current situation. Because the online learning process helps develop student interaction and collaboration as students share what they learn and influence each other.

4- Conclusion

This learning differs from previous one, where the combination of problem-based learning and revised Bloom's classification-oriented activities combined problem-based learning models with developed activities. These activities include: 1) referring to self-awareness of surrounding economic activity; 2) describing self-awareness of magnetism; 3) applying self-awareness of magnetism and gravity; 4) describing collages, mosaics, montages, and applications. Distinguish self-perception, 5) evaluate self-perception regarding attitudes toward tolerance towards diversity. 6) Confidence in creating collage and mosaic art. This learning activity allows students to actively participate in the given activities and problem-solving. Such learning provides students with opportunities to develop metacognitive skills and learning outcomes. However, this study can be deployed in greater numbers than at the time this study was conducted. Even with a larger sample size, this learning model is effectively used to improve students' metacognitive skills and learning outcomes.

Learning that uses a combination of problem-based learning models and learning activities aligned with the revised Bloom taxonomy can influence students' metacognitive skills and learning outcomes. Students are at the centre of their learning, so they are actively involved in the learning process. This learning activity develops students' metacognitive skills and provides an opportunity to reflect on what they know about themselves and to be honest and confident in their knowledge. Additionally, learning activities are organized by learning objectives to help students improve their learning outcomes. The results of this study are expected to contribute to the implementation of innovative learning processes to improve students' metacognitive abilities. These findings can be used as a reference for improving the quality of the learning process.

5- Declarations

5-1- Author Contributions

Conceptualization, I.G.A.L.P.; methodology, I.G.A.L.P. and I.W.W.; validation, I.W.W.; writing—original draft preparation, I.N.L.J.; writing—review and editing, I.W.W.; supervision, I.G.A.L.P. All authors have read and agreed to the published version of the manuscript.

5-2- Data Availability Statement

The data presented in this study are available in the article.

5-3- Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

5-4- Institutional Review Board Statement

This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of the Universitas Pendidikan Ganesha (Ganesha University of Education), Singaraja, Indonesia.

5-5- Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

5-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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