Local Genius Mabbelle: Analysis of Increasing Students' Metacognition Skills Through Augmented Reality-Based Educational Learning Media

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Abstract

Metacognitive skills is an essential component of Higher Order Thinking Skills (HOTS), are critical in equipping students to solve complex, context-based problems. A 2022 survey by the McKinsey Global Institute identifies metacognitive skills as a primary predictor of students' performance, particularly in adapting to the changes posed by the era of Society 5.0. Despite this importance, metacognitive skills among students in Indonesia remain low, many students struggle to comprehend material and complete tasks requiring high-level thinking. This study, conducted at UPT SMP Negeri 1 Kahu, employed a quantitative approach to evaluate the impact of Local Genius Mabbelle-based educational media, enhanced with Augmented Reality (Mabbelle-AR), on students' metacognitive skills. The research design included three groups for testing, a limited trial group, a broader trial group, and an experimental group. The assessment of metacognitive skills focused on three core indicators: planning, monitoring, and evaluating. Results indicate that students in the experimental group using Mabbelle-AR demonstrated an 81% improvement in metacognitive skills, while the control group exhibited a 60% increase. These findings highlight Mabbelle-AR efficacy as an educational tool for enhancing students' metacognitive skills, providing an innovative and culturally relevant solution to the persistent challenge of low HOTS levels among Indonesian students. The study suggests that Mabbelle-AR not only promotes critical thinking and problem-solving skills but also supports a culturally grounded approach to integrating technology in education, thereby preparing students with the necessary skills to navigate the complexities of Society 5.0.

Keywords: metacognition skills, augmented reality, local genius mabbelle

INTRODUCTION

Metacognition skills are concepts related to problem solving and the transfer of cognitive skills. This ability is integrated into eight fundamental pillars that underlie cognitive and psychophysiological mechanisms and contribute to the functioning of intelligence in all areas and the emergence of self-awareness and knowledge. Metacognition skills play an important role in the development of skills in the 21st century including problem solving, critical thinking, creative thinking, and reflective thinking as well as the ability to access information [1]. Metacognition skills are one of the thinking skills that involve several aspects of skills, such as planning components (function planning), self-control (self-monitoring), and evaluation (self-evaluation) [2-3]. In the field of education, the results of the McKinsey Global Institute survey in 2022 showed that Metacognition skills were identified as one of the main predictors of student performance in adapting to change, especially in facing the Society 5.0 era [4-5]. This is also supported by research [6] which found that metacognition skills are part of high-order thinking skills (HOTS) which are very important in helping students solve problems, especially contextual problems. Thus, learning that emphasizes these skills can significantly increase the effectiveness of learning carried out by teachers.

Previous research has shown that metacognition skills have a significant influence on students' mathematical abilities. Metacognition skills are very important for learning success because they allow students to manage cognitive abilities and identify weaknesses that need to be improved. Students can be encouraged to develop metacognition skills by increasing awareness of the importance of metacognition in improving academic achievement. However, the importance of metacognition skills is inversely proportional to the reality in the field today. Metacognition skills in Indonesia are generally still very low, where students have not been able to understand the subject matter and complete learning tasks, especially those that emphasize high-level thinking aspects [7-8]. This is in accordance with the findings of other studies that low metacognitive abilities of students cause a lack of student activity and make the learning process boring and saturated [9]. So, when students are asked thought-provoking questions when looking for solutions to solve problems, they tend to be unable to provide adequate explanations when answering these questions.

The low metacognition skills are also seen from the results of the National Examination for mathematics in Bone Regency which obtained a score of 47.71 [10]. This is one of the factors causing the low ability of students to solve mathematical problems. The AKM results obtained from the 2022 Public Education Report Card show that numeracy skills are below the minimum competency with the learning quality index still not supported by thinking activities [11]. The same problem also occurs in students in Bone Regency with a mathematics score of only 46.15 in the low category. This is in line with the results of observations during the School Field Introduction (PLP) activity at SMP Negeri 1 Kahu, where it was found that students were not yet able to plan solutions, monitor and critically evaluate a problem-solving process, especially in mathematics. Apart from the results of interviews with mathematics teachers, weak metacognition skills are also seen from the results of the Summative Assessment of students on the subject of flat shapes which showed a low AKM score (50%). Therefore, educational learning innovations are needed to improve students' metacognition skills. The solution that can be applied to increase the activeness of the teaching and learning process is the use of educational learning media that can stimulate students to carry out thinking activities that combine learning and playing in the form of utilizing traditional games that are part of Local Genius (local wisdom), such as the Mabbelle game which emphasizes thinking activities and solution planning.

In the process of learning mathematics, the application of traditional games such as local genius Mabbelle can be useful to make learning more interesting and support thinking, communication, and collaboration skills [12-13]. However, if this game is applied, it will require complex media and a large location and its application is considered quite difficult. Therefore, this study was conducted by integrating the Bugis Mabbelle game with Augmented Reality technology. Augmented Reality is a technology that combines virtual objects with the physical environment to provide a display that matches the real world [14]. The use of Augmented Reality technology can be an interesting and effective media to introduce traditional games to students, as well as to increase interest and motivation in learning local culture. The integration between Augmented Reality and local wisdom (local genius) in this research will be a supporting media in providing an overview of the Mabbelle game pattern on flat building material through 3D visualization.

METHODOLOGY

This type of research is quantitative descriptive by analyzing the level of metacognition skills of students using educational learning media based on Local Genius Mabbelle assisted by Augmented Reality (Mabbelle-AR). The sampling technique used purposive sampling and selected students of class VII at one of the State Junior High Schools in Bone Regency, namely SMP Negeri 1 Kahu with classification VII E as a limited trial class, VII D as a wide trial class and class VII C as an experimental class. The instruments used in this study include metacognition skills ability tests with three indicators, namely (1) Planning, (2) Monitoring, and (3) Evaluation. The following is a description of the metacognition skills indicators.

Table 1. Metacognition skills indicators

Indicators	Description
Planning	Students' ability to determine information in planning the problem-solving process.
Monitoring	Students' ability to organize and analyze information in solving problems.
Evaluating	Students' ability to examine and conclude solutions to problems.

The research instruments used in this study were observation, interviews, written tests, and documentation. The written test used was a metacognition skills test consisting of 5 essay questions arranged based on metacognition skills indicators. Before being used to test the control class and the experimental class, the test instrument was first tested for validity and reliability. Validity testing used expert judgment techniques while reliability testing was carried out by conducting trials on other classes not used in the study.

The data analysis technique used is descriptive statistics to describe students' metacognition skills in each class. The gain score assessment criteria used in this study to measure students' metacognition skills are based on the category index contained in Table 2.

Table 2. Metacognition Skills Category Index

Value (%)	Category
$70 \leq \bar{x} \leq 100$	High
$50 \leq \bar{x} < 70$	Medium
$0 \leq \bar{x} < 50$	Low

RESULTS AND DISCUSSION

Needs Analysis

The results of the needs analysis activities in class VII at UPT SMP Negeri 1 Kahu through observation and interviews supported by the results of the pretest in mathematics subjects, especially on flat shapes, showed that students were not yet able to plan solutions, monitor and critically evaluate a problem-solving process, then students were not fully able to understand questions based on

contextual and high order thinking skills, especially problems that emphasize metacognition skills. Students also often have difficulty connecting theoretical concepts with real situations and are less skilled in using the right strategies to solve complex problems, ultimately affecting their ability to achieve optimal learning outcomes. Students often have difficulty planning steps to solve problems, are less effective in monitoring their own progress during the solving process, and are unable to make critical assessments of the final results of a problem solving. This results in students being unable to identify weaknesses and errors in the learning process, and being unable to apply better strategies in the future. In addition to these problems, the lack of use of educational and interactive teaching media is also a major factor in the low metacognition skills of students. So far, teachers have only used media in the form of projectors with the help of visual powerpoint media to present learning materials. This limited media is less able to facilitate dynamic and in-depth interactions between students and the material being taught, so it is necessary to use more varied and interactive teaching media with a collaborative learning system that can stimulate active involvement and reflection of students.

Based on the results of the needs analysis that has been carried out, it can be seen that the learning process carried out in class VII UPT SMP Negeri 1 Kahu, especially in mathematics, shows that the learning process that is taking place still shows a lack of student activity in learning, and most students still memorize learning materials without understanding what is being taught. As a result, when students are given questions that stimulate the thinking process in finding solutions to problem solving, students tend to be less able to provide good explanations in answering questions. Several factors that can influence this are the learning process which is still teacher-centered, and the emphasis on memorization rather than understanding concepts, as well as the lack of use of learning media that can increase student interest and activity in learning. This is in line with research by [15] which states that the existence of learning media has a great impact on students and teachers in the teaching and learning process as an effort to transfer knowledge to students in order to achieve learning goals. In addition, [16] also explained the importance of using learning media, namely that it can greatly help the effectiveness of the learning process and the delivery of messages and content of learning materials. This is because the right learning media can bring and arouse a sense of joy and happiness (joyfull) to students and renew enthusiasm, as well as help in strengthening knowledge in the minds of students and enlivening the teaching and learning process. In addition, [17] also showed that the use of varied and interesting learning media can help students understand concepts more deeply and apply them in various contexts. Therefore, innovation in learning media is needed to improve the quality of the teaching and learning process in class VII UPT SMP Negeri 1 Kahu, so that students can plan, monitor, and evaluate each problem given until students can find the right solution, especially in the mathematics subject of flat shapes.

Gain Score Test for Improving Students' Metacognition Skills

Analysis of the increase in metacognition skills in this study is seen from the results of the pre-test and post-test. The metacognition skills test used was an essay question consisting of five questions. The results of the comparative analysis of the pre-test and post-test of the level of students' metacognition skills can be seen in table 3 below.

Table 3. Comparison of pre-test and post-test results

Class	Pre-Test	Post-Test
Limited Trial	30,11	60,20
Extensive Trial	33,22	70,34
Experimental Test	31,15	92,24
Control Class	43,12	70,23

The results of the gain analysis and N-Gain Score of students' metacognition skills in each test can be seen in the graph in Figure 1 below.
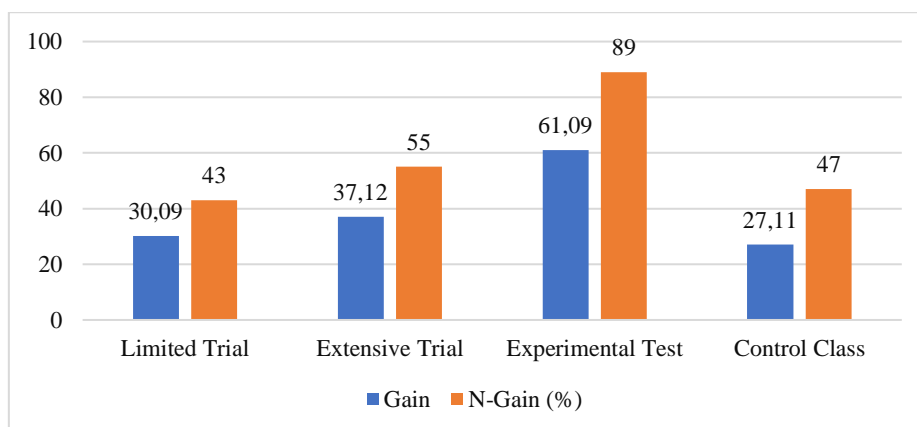

Figure 1. Comparison of gain and N-gain score

The results presented in Table 2 and Figure 1 above show that in the implementation of limited trials in class VII E, the pre-test results indicated that the level of students' metacognition skills was still low with an average of 30.11. Then, after treatment was carried out by implementing educational learning media based on Local Genius Mabbelle assisted by Augmented Reality, students' skills increased, namely 60.20 with an N-gain score of 43%. In the extensive trial in class VII D, the average student score was 33.22. After treatment, there was an increase in students' skills, namely 70.34 with an N-Gain score of 55%. Then, in the implementation of the experimental test in class VII C, the average score was 31.15, after treatment it was 92.24 with an N-Gain of 89%. Meanwhile, the level of students' metacognition skills in the control class, seen from the pre-test results, was still very low, but higher than the trial and experimental classes, namely 43.12. The results of the control class post-test were not much different from the previous results, which were 70.23 with an N-Gain of 47%. The results of this analysis indicate that before the implementation of learning, it was seen that students' metacognition skills were still very lacking. However, after treatment using educational learning media based on Local Genius Mabbelle assisted by Augmented Reality in each test class (limited trial, extensive trial, experimental test) showed that the percentage of students' metacognition skills increased as seen from the results of the N-Gain analysis.

Analysis of Students' Metacognition Skills Indicators

The improvement of students' metacognition skills can also be seen from three indicators of metacognition skills, namely planning, monitoring and evaluating, where these three indicators are

included in each question (test) given. Through a series of learning stages using this learning media, students are slowly able to hone their metacognition skills including skills in determining information in planning problem solving, organizing and analyzing information in solving problems, and checking and concluding problem solutions. Students' skills in carrying out step-by-step problem solving occur when the teacher provides the application of media in the form of Mabbelle-AR which contains 3D visualization of the Mabbelle game which has a very innovative flat shape pattern, so that students can identify the shape and pattern of the path which is integrated in the learning process. The analysis of the improvement of students' metacognition skills in each indicator after the application of educational learning media based on Local Genius Mabbelle assisted by Augmented Reality can be seen in Figure 2 below.
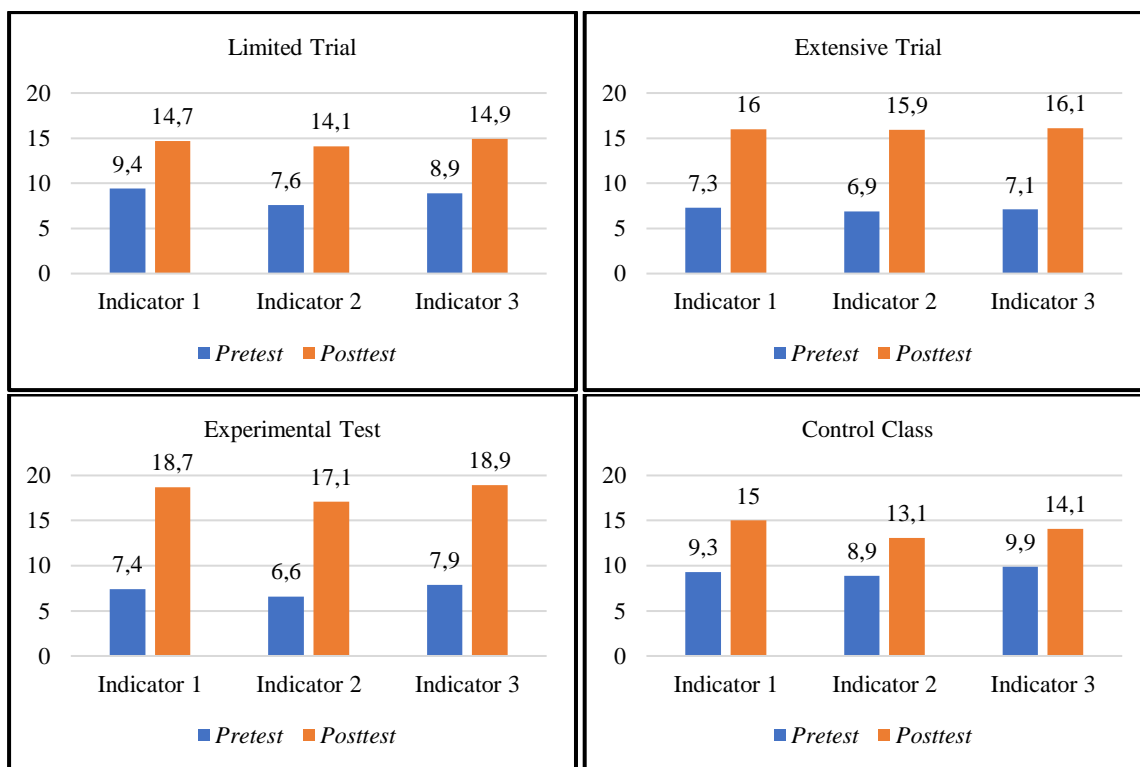

Figure 2. Comparison of Metacognition Skills Indicators

Based on the comparison chart of metacognition skills indicators above, it is clear that students have difficulty in solving questions on the second indicator, namely monitoring the problem-solving process. In each test, students are able to analyze important information to remember and decide what steps to take next, but are still often mistaken if they encounter obstacles in the process of implementing problem-solving solutions. This result has increased after the application of educational learning media based on Local Genius Mabbelle assisted by Augmented Reality, students showed progress where initially they were less able to organize the steps needed with the right procedures. However, after going through learning with concrete stages and integration of the shape and pattern of the Mabbelle game path which is closely related to the flat shapes of squares, rectangles, semicircles and trapezoids and example questions that can strengthen knowledge in solving problems, students began to understand the procedures they went through until they were able to decide the steps to be taken next whether changes were needed or moving to other instructions, and find alternative steps for

other solutions if they encountered an obstacle. This indicates that the application of educational learning media based on Local Genius Mabbelle assisted by Augmented Reality can significantly improve students' metacognition skills. Metacognition skills are awareness of the learning process, planning, strategy selection, monitoring the learning process, and awareness of being able to correct one's own mistakes to be able to check whether the strategy used is useful or not [18-19].

Metacognition skills are high-level cognitive abilities needed for knowledge management, where students are required to set their own learning goals and determine appropriate learning strategies to achieve learning goals [20-21]. One of the factors that influences metacognition is students' anxiety in facing mathematics lessons, which has an impact on students' awareness in thinking. High math anxiety can make students lose concentration in learning, and cannot focus their minds on solving problems [22]. This is also in line with the problems encountered in grade VII students at SMP Negeri 1 Kahu (Needs Analysis Results). Students tend to memorize more material in textbooks, but do not understand every material taught. As a result, students who are required to be responsible for each answer experience difficulties that result in weak Metacognition skills of students. Therefore, this research by implementing educational learning media based on Local Genius Mabbelle assisted by Augmented Reality can help students in planning, monitoring and evaluating problems to create appropriate solutions through learning stages in the form of integration of Bugis cultural values such as Sipatudang, Sipattuju, Sipalolongeng and Sipalempu which are elaborated into stages of exploration, connection, problem solving and review in applying contextual visualization of the Mabbelle game path pattern in flat building material.

The implementation of educational learning media based on Local Genius Mabbelle assisted by Augmented Reality (Mabbelle-AR) can increase the interest and activeness of students in participating in the teaching and learning process, this is because in this media students carry out identification activities on the form of Mabbelle game track patterns with flat shapes accompanied by the formulas used, then also contains Bugis cultural values that should be owned by the community and need to be preserved in the current generation. Thus, the innovation of educational learning media that is created can make students more active in the learning process, in order to create learning that is not only meaningful (Meaningfull Learning), but also enjoyable learning (Joyfull Learning), and supports the strengthening of cultural resilience in the Bugis community.

CONCLUSIONS

The results of this study indicate that the use of Local Genius Mabbelle-based learning media with Augmented Reality (Mabbelle-AR) significantly improves students' metacognition skills in learning mathematics on flat geometry material. The average metacognition skills of students in the experimental class increased from 31.15 to 92.24 with an N-Gain of 89%, compared to the control class which only increased from 43.12 to 70.23 (N-Gain 47%). The higher increase in the experimental and trial classes indicates that the use of Mabbelle-AR contributes more to improving metacognition skills compared to conventional methods. This media not only improves the planning, monitoring, and evaluation aspects, but also makes learning more interesting through 3D visualization of the traditional Mabbelle game. In addition, the integration of Bugis cultural values enriches the learning experience, strengthens cultural resilience, and connects students with local culture. These results support

Mabbelle-AR as an effective learning media to prepare students to face the Society 5.0 era, with a significant increase in critical thinking skills compared to traditional learning methods.

AUTHOR CONTRIBUTIONS

Sartika Sari Dewi, Andi Muhammad Irfan Taufan Asfar, Andi Muhamad Iqbal Akbar Asfar, Muhlis, and Andi Nurannisa contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

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