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Students' Mathematical Creative Thinking Ability in LAPS-Heuristic Learning Model with Performance Assessment and Open-Ended Questions

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Abstract. *This quantitative research with a quasi-experimental design demonstrates several significant findings regarding the quality of LAPS-Heuristic learning with performance assessment and open-ended questions of students' Mathematics' Creative Thinking Ability (MCTA): (1) In the planning phase, the validation of learning materials and research instruments was classified as at least satisfactory; (2) During the implementation phase, the quality assessment sheets from the first to the third meetings were as at least satisfactory; (3) Student's response to LAPS-Heuristic learning combined with performance assessment and open-ended questions was notably positive, achieving a rating of 70.75%, which is categorized as strong; and (4) During the assessment stage, the results obtained from the LAPS-Heuristic learning combined with performance assessment and open-ended questions, indicate several notable findings concerning students' MCTA. First, the completion rate for students engaged in LAPS-Heuristic learning combined with performance assessment and open-ended questions surpassed 75%. Second, the average of students' MCTA who participated in LAPS-Heuristic learning, combined with performance assessment and open-ended questions, demonstrated significant improvement compared to those who participated in LAPS-Heuristic learning. Third, the proportion of experiment class students exhibiting stronger MCTA than the control class students.*

Keywords: *MCTA, LAPS-Heuristic, Performance Assessment, Open-Ended.*

INTRODUCTION

To tackle the challenges of the 21st century, students must cultivate essential thinking skills. Laar et al. (2017) classify these skills into seven distinct areas: technical, information management, communication, collaboration, creativity, critical thinking, and problem-solving. The study highlights the vital importance of creative thinking ability. Regrettably, the development of MCTA among students in Indonesia remains a significant concern. The evidence comes from PISA, which evaluates students' mathematical literacy globally in areas such as quantity,

uncertainty, change or relationships, and space or shape. In the most recent 2022 PISA results, Indonesia ranked 68th out of 81 countries, achieving a mathematics score of 379 (Setiawan et al., 2024). Further research conducted by Wang et al. (2011) has demonstrated a positive correlation between creative thinking and both reading and writing skills. Additionally, research by Sebastian & Huang (2016) indicates a strong relationship between students' MCTA and performance on the PISA.

Research by Tabach & Friedlander (2017) suggests that students' MCTA greatly influences their conceptual understanding during the learning process. Students who exhibit heightened creative thinking tend to employ flexible and innovative strategies when addressing problems rather than relying solely on traditional methods taught by educators (Al-Zu'bii et al., 2017; Heriyanto et al., 2021). According to Doleck et al. (2017), the core elements of MCTA consist of fluency, flexibility, originality, and elaboration. The significance of creative thinking in mathematics education underscores the necessity for an enabling environment and conducive learning situations to cultivate students' creative capabilities. As noted by Shriki (2010), educators must design and implement learning environments that actively promote the development of creativity among students.

A teacher must be able to organize and select appropriate learning strategies (Beswick & Fraser, 2019). One particularly effective approach for enhancing students' MCTA is Logan Avenue Problem Solving (LAPS)-Heuristic learning. The LAPS-Heuristic learning model encompasses several essential steps: firstly, understanding the problem; secondly, planning an effective problem-solving strategy; thirdly, implementing the plan; and finally, re-evaluating the results obtained (Azwardi & Sugiarni, 2019; Shoimin, 2014). As noted by Purba and Sirait, referenced by Sanaki (2020), this model emphasizes a student-centered approach, empowering learners to construct their understanding and conclusions. Furthermore, Ningsih et al. (2021) indicate that the LAPS-Heuristic model actively engages students in learning, promoting independent learning. This engagement fosters the development of MCTA, enabling students to understand, formulate,

discover, and reflect on their approaches to problem-solving (Anggrianto et al., 2016; Kaur & Wong, 2011). Consequently, the LAPS-Heuristic learning model facilitates independent learning and enhances students' MCTA.

Appropriate assessments should support the use of appropriate learning models. Masrukan (2017) stated that assessment systematically collects and analyzes information to improve student learning, which is carried out continuously. One form of alternative assessment is performance assessment. According to Badriani et al. (2015), performance assessments involve having students engage in specific activities while teachers observe the quality of their performance and learning outcomes. This type of assessment requires students to demonstrate and apply their knowledge in various contexts based on established criteria (Owen, 2016).

Additionally, Tejeda & Gallardo (2017) emphasize that performance assessments help determine whether students can connect their knowledge to real-life situations. Peck et al. (2014) also found that performance assessments can enhance students' understanding of their strengths and weaknesses. Moreover, utilizing performance assessments can stimulate students' interest in learning and increase their active engagement in the educational process (Mahendra, 2016; Masrukan & Elmagustilla, 2020).

The problems presented during learning with the LAPS-Heuristic model and performance assessment involve open-ended questions. These questions allow students to express their ideas, fostering creative thinking (Irawan & Surya, 2017). MCTA refers to the ability to produce something new and find varied solutions to open mathematical problems (Yuniarti et al., 2021). Agustina et al. (2023) show that students' MCTA use open-ended questions better than non-open-ended questions in a class. This statement is reinforced by the findings of (Waluyo, 2018; Wanelly & Fauzan, 2020), which show that students have better MCTA if taught using an open-ended approach.

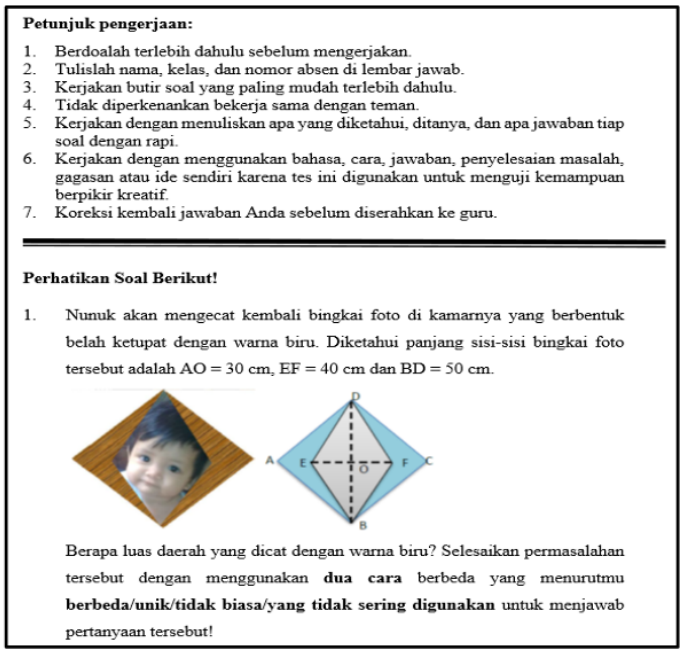
This study aims to analyze the quality of mathematics learning after implementing the LAPS-Heuristic model integrated with performance assessment and open-ended questions in enhancing students' MCTA. The findings of this

research are expected to serve as a valuable source of information or input for teachers in delivering lessons that are often perceived as difficult to understand by students. Using the LAPS-Heuristic learning model, combined with performance assessment and open-ended questions, can create a more comfortable and engaging learning environment, thereby fostering the development of students' MCTA. In this context, students are encouraged to explore and express their thoughts freely and develop multiple strategies to solve problems without being constrained by the teacher's explanations.

RESEARCH METHOD

The research method utilized in this study is quantitative research with a quasi-experimental design. The population for this study consists of 7th-grade students at Junior High School 1 Tayu. The sample includes Grade VII C students, the experimental group receiving LAPS-Heuristic learning with performance assessment and open-ended questions, and Grade VII D students, the control group receiving LAPS-Heuristic learning. This sampling was conducted using a cluster random sampling technique.

Data collection for this study was conducted using an essay-based test instrument focusing on geometry topics. The test items assessed students' MCTA, particularly fluency, flexibility, originality, and elaboration. The following is an example of a test item designed to assess students' MCTA on geometry topics.



Petunjuk pengerjaan:

1. Berdoalah terlebih dahulu sebelum mengerjakan.
2. Tulislah nama, kelas, dan nomor absen di lembar jawab.
3. Kerjakan butir soal yang paling mudah terlebih dahulu.
4. Tidak diperkenankan bekerja sama dengan teman.
5. Kerjakan dengan menuliskan apa yang diketahui, ditanya, dan apa jawaban tiap soal dengan rapi.
6. Kerjakan dengan menggunakan bahasa, cara, jawaban, penyelesaian masalah, gagasan atau ide sendiri karena tes ini digunakan untuk menguji kemampuan berpikir kreatif.
7. Koreksi kembali jawaban Anda sebelum diserahkan ke guru.

Perhatikan Soal Berikut!

1. Nunuk akan mengecat kembali bingkai foto di kamarnya yang berbentuk belah ketupat dengan warna biru. Diketahui panjang sisi-sisi bingkai foto tersebut adalah AO = 30 cm, EF = 40 cm dan BD = 50 cm.

Berapa luas daerah yang dicat dengan warna biru? Selesaikan permasalahan tersebut dengan menggunakan **dua cara** berbeda yang menurutmu **berbeda/unik/tidak biasa/yang tidak sering digunakan** untuk menjawab pertanyaan tersebut!

Figure 1. Example of MCTA Test

This study's data analysis comprises a prerequisite test analysis and an evaluation of the MCTA test results. The prerequisite test analysis incorporates three key components: 1) Normality Test to determine whether both sample groups are drawn from a normally distributed population, 2) Homogeneity Test to examine whether the variances within the sample groups are homogeneous, 3) Average Difference test too ascertain whether the sample groups share the same baseline abilities. All tests were conducted using a significance level of 0.05. The findings indicate that both sample groups originate from a normally distributed population, exhibit homogeneity in variances, and demonstrate similar baseline abilities. This report analyzes data from the MCTA test results. The primary objective is to evaluate the effectiveness of LAPS-Heuristic learning with performance assessment on students' MCTA.

RESULT AND DISCUSSION

The quality of learning is seen from the process and results of implementing learning. The interaction between students and teachers characterizes good learning quality, and learning resources in a learning environment, to achieve learning goals.

The quality of learning that is assessed consists of: (1) the planning stage, (2) the implementation stage, and (3) the assessment stage.

The planning stage includes the preparation of learning devices and research instruments. The learning devices compiled include ATP, teaching modules, and LKPD. The research instrument compiled is a mathematical, creative thinking ability test question. The expert validated the learning devices and research instruments. Based on the validation results of devices and instruments by expert validators with good criteria. These results indicate that the devices and instruments made are suitable for use.

The implementation of learning, in general, has gone well with the teaching module that has been created. In the first meeting, the implementation of learning scored 93,75%, which is very good. In the second meeting, the implementation of learning scored 95,31%, which is very good. In the third meeting, the implementation of learning scored 95,31%, which is very good. Based on observations, the implementation of learning is in the very good category. The following is a graph of the implementation of learning.

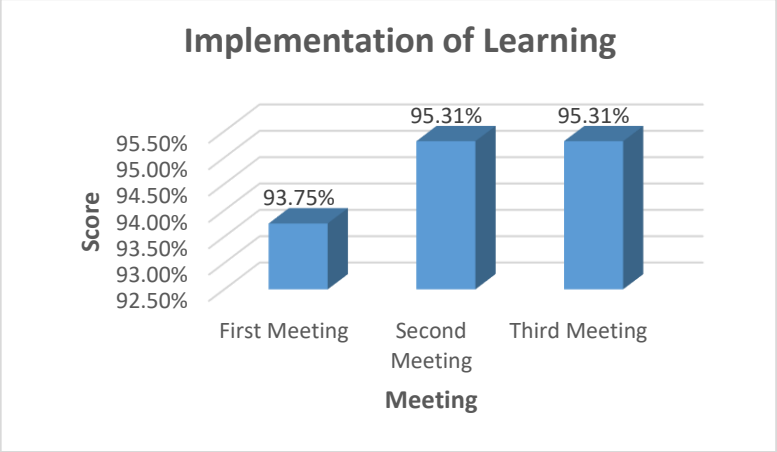


Figure 2. Implementation of Learning

The first stage of learning assessment was carried out by providing a questionnaire of student responses to LAPS-Heuristic learning with performance assessment and open-ended questions after the learning was completed. The response of students participating in LAPS-Heuristic learning with performance assessment and open-ended questions gave a positive response with a value of 70.75%, which is included in the strong category. This result means that students

feel happy and comfortable with LAPS-Heuristic learning with performance assessment and open-ended questions, so that it can motivate students to learn.

The quantitative learning assessment stage is of quality if evaluating learning outcomes is effective. LAPS-Heuristic learning with performance assessment and open-ended questions is said to be effective if: (a) students complete learning towards MCTA classically more than 75%, (b) the average MCTA of students in LAPS-Heuristic learning with performance assessment and open-ended questions is better than the average MCTA of students with LAPS-Heuristic learning, and (c) the proportion of MCTA of students in LAPS-Heuristic learning with performance assessment and open-ended questions is more than the proportion of MCTA of students with LAPS-Heuristic learning.

Before testing the hypothesis, a prerequisite test, namely the normality test using *R*, must be done. The results of the normality test of MCTA are presented in Figure 3 below.

```
> library(nortest)
> pearson.test(Result_MCTA$`Posttest Eks`)

        Pearson chi-square normality test

data:  Result_MCTA$`Posttest Eks`
P = 5, p-value = 0.4159

> pearson.test(Result_MCTA$`Posttest Kontrol`)

        Pearson chi-square normality test

data:  Result_MCTA$`Posttest Kontrol`
P = 11, p-value = 0.05138
```

Figure 3. Normality Test

The normality test was obtained for experiment class $p\text{-}value = 0.4159 > 0.05$ and $p\text{-}value = 0.05138 > 0.05$ for controlled class, hence H_0 is accepted. Thus, the experiment and control class data are normally distributed.

The first hypothesis in this study is a classical completeness test using a one-sample proportion test (one tail, right side). The classical completeness in this study is if more than 75% of students use LAPS-Heuristic learning with performance assessment and open-ended questions to get a score with a minimum limit of 70. The results of the classical completeness test of MCTA are presented in Figure 4 below.

```
> prop.test(29,32,0.75,alternative = "greater",conf.level = 0.95)

        1-sample proportions test with continuity correction

data:  29 out of 32, null probability 0.75
X-squared = 3.375, df = 1, p-value = 0.0331
alternative hypothesis: true p is greater than 0.75
95 percent confidence interval:
 0.7678622 1.0000000
sample estimates:
      p
0.90625
```

Figure 4. Classical Completeness Test

Based on the result, $p\text{-}value = 0.0331 < 0.05$, then H_0 is rejected. Thus, the proportion of students in LAPS-Heuristic learning with performance assessment and open-ended questions who complete the test is more than 75%.

The second hypothesis is the average difference test. Before testing the average difference test, a prerequisite test, namely the variance difference test, must be done using the Levene test with *R*. The results of the variance difference test of MCTA are presented in Figure 5 below.

```
> library(car)
> leveneTest(Result_MCTA_2$`Posttest Eks`, Result_MCTA_2$Code, center
=mean)
Levene's Test for Homogeneity of Variance (center = mean)
      Df F value Pr(>F)
group  1  1.3645 0.2472
      62
Warning message:
In leveneTest.default(Result_MCTA_2$`Posttest Eks`, Result_MCTA_2$Cod
e,  :
  Result_MCTA_2$Code coerced to factor.
```

Figure 5. Variance Difference Test

In variance difference, the test obtained that p-value = 0.2472 > 0.05. H_0 is accepted. Thus, the variance of the two classes is the same.

The average difference test (one-tail, right side) was conducted to test whether the average of students' MCTA in the class experiment was higher than the average of students' MCTA in the class control. The results of the average difference test of MCTA are presented in Figure 6 below.

```
> t.test(Result_MCTA$`Posttest Eks`,Result_MCTA$`Posttest Kontrol`,al
ternative = "greater",mu=0,paired = FALSE,var.equal = TRUE,conf.level
 = 0.95)

        Two Sample t-test

data:  Result_MCTA$`Posttest Eks` and Result_MCTA$`Posttest Kontrol`
t = 5.5872, df = 62, p-value = 2.74e-07
alternative hypothesis: true difference in means is greater than 0
95 percent confidence interval:
 11.77801      Inf
sample estimates:
mean of x mean of y
 80.36875  63.57031
```

Figure 6. Average Difference Test

Based on the result, $p\text{-}value = 2.74 \times 10^{-7} < 0.05$, then H_0 is rejected. Thus, the average of students' MCTA that used the LAPS-Heuristic learning model with performance assessment and open-ended questions is more than that of students' MCTA using the LAPS-Heuristic learning model.

The third hypothesis is the proportion difference test. The proportion difference test (one tail, right side) tests the proportion of students who achieved mastery learning using the LAPS-Heuristic learning model, higher than those who achieved mastery learning using Direct Instruction learning or not. The results of the proportion difference test of MCTA are presented in Figure 7 below.

```
> prop.test(x=c(29,8),n=c(32,32),alternative = "greater",conf.level
 = 0.95,correct = TRUE)

        2-sample test for equality of proportions with
        continuity correction

data:  c(29, 8) out of c(32, 32)
X-squared = 25.626, df = 1, p-value = 2.072e-07
alternative hypothesis: greater
95 percent confidence interval:
 0.4732235 1.0000000
sample estimates:
 prop 1  prop 2
0.90625 0.25000
```

Figure 7. Proportion Difference Test

Based on the result, $p\text{-}value = 2{,}072 \times 10^{-7} < 0.05$, then H_0 is rejected. Thus, the proportion of students who achieve mastery learning with the LAPS-Heuristic learning model with performance assessment and open-ended questions is more than that of students who achieve mastery using the LAPS-Heuristic learning model.

The research findings of (Aulia & Karomah, 2021; Husna et al., 2018) indicate that the LAPS-Heuristic learning model effectively enhances students' MCTA. Putri et al. (2020) show that the study results of the class taught with performance assessment have positively contributed to developing or enhancing students' creative thinking. Research by Agustina et al. (2023) and Rahayuningsih et al. (2021) also shows that the MCTA of students taught using open-ended questions is better than the MCTA of students taught without open-ended questions. These findings are consistent with the present study, in which students taught using the LAPS-Heuristic model integrated with performance assessments and open-ended questions demonstrated higher levels of MCTA. This study suggests that

combining LAPS-Heuristic learning with performance assessments and open-ended questions provides a more effective environment for nurturing students' MCTA.

However, although the results of this study indicate that the combination of LAPS-Heuristic learning with performance assessment and open-ended questions is good in developing MCTA, several limitations need to be considered. Using the LAPS-Heuristic method with performance assessment and open-ended questions has great potential; implementing this method in different contexts or with students with diverse backgrounds may require further adjustment. Furthermore, this study has not measured in depth other external factors, such as student motivation and learning environment support, which may also affect the development of MCTA.

CONCLUSION

Based on the research findings and discussion, it can be concluded that implementing LAPS-Heuristic learning integrated with performance assessment and open-ended questions demonstrates high quality in supporting students' MCTA. This conclusion is supported by the following: (1) At the planning stage, the validation results of learning tools and research instruments fall into the satisfactory category; (2) At the implementation stage, the quality of learning from the first to the third meeting is consistently assessed as at least satisfactory category; and (3) At the assessment stage, student responses toward the use of performance assessment in LAPS-Heuristic learning indicate a strong positive perception, with a response rate of 70.75%.

Furthermore, the effectiveness of LAPS-Heuristic learning with performance assessment and open-ended questions in enhancing MCTA is evidenced by: (1) the proportion of students achieving mastery exceeds 75%; (2) the average MCTA score of students taught with this integrated approach is higher than those taught with LAPS-Heuristic; and (3) the proportion of students achieving MCTA mastery is greater in the group taught using LAPS-Heuristic with performance assessment and open-ended questions compared to the group taught using only the LAPS-Heuristic model.

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