Critical thinking skills in mathematics

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Abstract. Teachers' low mathematical critical thinking skills (MCTS) resulted in students' low MCTS in the learning process. A teacher needs to have a good foundation of MCTS so that they can pass on their MCTS to their students. This study aims to improve the teaching and learning activities of teachers through prospective teachers and to find out whether there is an effect of the interaction between learning and Mathematical Prior Knowledge (MPK) of prospective teachers on the achievement of the MCTS. The solution offered in the learning process is Realistic Mathematics Education based on Emergent Modeling (RME-EM). The research method used is quantitative research methods. The research sample is prospective teachers at one of the private universities in West Java, as many as 51 people. The result of the research is that the achievement of the student teaching and learning activities of prospective teachers who get RME-EM learning is better than the achievement of the MCTS of prospective teachers who get conventional learning. On the influence of the interaction between learning (RME-EM and Conventional) and MPK (high, medium, and low) prospective teachers on the achievement of MCTS, it is found that there is an influence on the achievement of student teaching and learning activities based on learning and MPK, but there is no interaction between learning and MPK towards the achievement of prospective teachers. RME-EM learning can be implemented at various student levels and is quite successful in improving teaching and learning activities for prospective teachers. However, RME-EM learning activities are not sufficient to have a significant impact on the interaction between learning and MPK on prospective teachers. RME-EM can be a solution for teachers who want to improve their students' MCTS in the classroom.

1. Introduction

In the 2013 Curriculum, students' mathematical abilities and attitudes have an important role in shaping students' mindsets in solving problems [1]. The mathematics learning objectives listed in the 2013 Curriculum emphasize the modern pedagogical dimension [2], namely the scientific approach. Mathematics learning activities carried out using this approach are designed in such a way as to make learning more meaningful. In its implementation, students as learning subjects, competency-oriented learning, learning emphasize knowledge and skills in a balanced manner, and learning will be better at using technological means [3]. The stages of student learning activities consist of observing, asking, trying, reasoning, presenting and creating [4, 5].

Improving the quality of mathematics learning is carried out not only because of the urgency of mathematics [6] in other branches of science, but also to improve the mathematical abilities of Indonesian students. The ability of students to solve problems that require problem identification, make various thought
conjectures, choose appropriate strategies, find relationships between material content, reason, prove, re-
examine, analyze processes and results, and generalize conclusions, are still below average [7]. Some of the 
students' abilities mentioned are part of the indicators of critical thinking skills. So that we can know that 
students' mathematical critical thinking skills are still low.

Several previous studies have revealed the problem of a teacher's low mathematical critical thinking 
ability, resulting in the learning process not going well. The low ability of the teacher's mathematical critical 
thinking results in students not having the opportunity to see, identify, evaluate, and analyze with their 
abilities [8-10]. Therefore, it is necessary to have alternative learning solutions that can be used as a tool to 
improve students' mathematical critical thinking skills.

The Realistic Mathematics Education (RME) approach is an alternative learning solution that is 
considered to be able to solve the problems in this study, even though RME is not a new learning innovation. 
The RME approach is expected to improve the quality of learning for student teacher candidates. RME 
provides opportunities for student-teacher candidates to better understand the process of student transition in 
learning [11-14], because learning is more student-centered, in this case, student-teacher candidates. Through 
RME learning, the researcher conducted a theoretical study with the guidance of a supervisor in designing 
an estimated series of mathematics learning activities (Hypothetical Learning Trajectory / HLT) based on 
Emergent Modeling on some junior high school materials.

Based on these descriptions, it is necessary to conduct an in-depth study of the mathematical critical 
thinking skills (MCTS) and to what extent the application of RME-EM learning affects prospective teacher 
students in improving students' mathematical critical thinking skills. For this reason, researchers are 
interested in conducting research with the following problem formulations: a. Is the achievement of the 
student-teacher teaching and learning activities who get RME-EM better than prospective teacher students 
who get Conventional ?; and b. Is there an effect of the interaction between learning (RME-EM and 
Conventional) and Mathematical Prior Knowledge (MPK) on the achievement of MCTS?

2. Method
This study aims to see the achievement of student teaching and learning activities of prospective teacher 
students, so the research method used is quantitative research methods, namely quasi-experimental [15]. 
In this study, researchers have revealed various descriptions of what is the problem in this study as well 
as relevant theories and research that support this research. The formulation of the problem under study 
has focused on the achievement of MCTS at the institutional level. The population in this study were all 
students of the Undergraduate Mathematics Education Study Program at private LPTK in West Java 
province who took the Basic Education Mathematics Capita Selecta course I in the odd semester of the 
2019/2020 academic year.

Based on the research objectives, it is necessary to take a research sample of two classes as a means 
of implementing two learning models. The research sample taken was two classes of students in the 
Mathematics Education Study Program of the Indonesian Institute of Education, Garut, consisting of 51 
person. Class A with 26 prospective teachers as the experimental class and class B with 25 prospective 
teachers as the control class. The sample selection technique in this study was carried out by purposive 
sampling. The use of this sample selection technique was carried out because the researcher saw that 
these two classes had similar characteristics, and the character of students in these two classes was 
thought to have a good carrying capacity for the course of the research. Therefore, through this purposive 
sampling, the research sample taken is by the research objectives and can solve research problems and 
can provide a representative assessment.

Analysis of test result data is intended to determine the achievement of the MCTS of prospective 
teachers. The stages used in analyzing the data are based on the formulation of the research problem and 
can be analyzed quantitatively by using inferential statistical analysis.

2.1. Research Design
The research design for quantitative methods in this study used a quasi-experimental design in the form 
of a Nonequivalent Control Group Design. In this quasi-experiment, the subjects were not grouped with 
pure randomness, but the researchers accepted that the subjects were modest [16].
2.2. MCTS Test Research Instruments

The mathematical critical thinking ability test is used to measure mathematical critical thinking skills based on the indicators contained in the components of mathematical critical thinking skills, namely: 1) Problem identification (asking questions, identifying information and ideas, compiling information); 2) Strategy (considering alternatives carefully, applying ideas into action, thinking of various possibilities); 3) Reflection (re-checking the process, doing self-reflection, transferring solutions into new information); and 4) Analysis (applies logic, makes thorough conclusions, evaluates processes and results). The material that is being tested is focused on selected materials in junior high schools to get more detailed and specific results.

3. Results and Discussion

3.1. Results

The analysis of the achievement of the MCTS begins with a test of the difference in the average teaching and learning achievement of student-teacher candidates between the RME-EM and Conventional groups. But beforehand, it is necessary to know in advance that the test for normality of the scores for the achievement of the student teaching and learning activities of prospective teachers in the two learning groups as a whole, the results are presented in Table 1 below.

Table 1. Recapitulation of the Results of the Normality Test of Student Teacher Training and Education Achievement in Both Learning Groups.

| Learning   | Shapiro-Wilk Statistic | df | p-value (sig. 2-tailed) |
|------------|------------------------|----|-------------------------|
| RME-EM     | 0.936                  | 26 | 0.109                   |
| Conventional | 0.974                | 25 | 0.754                   |

Based on Table 1, it can be seen that the p-value (sig. 2-tailed) for RME-EM learning and conventional learning is greater than 0.05 so that the data is normally distributed. Because the data from the two learning groups were normally distributed, the average difference test was continued with the homogeneity test. The recapitulation of the results of the homogeneity test of the variance of student-teacher training activities data is presented in Table 2 below.

Table 2. Recapitulation of Homogeneity Test Results of Student Teaching and Learning Activities for Prospective Students in Both Learning.

| Learning   | Levene Statistic | df | p-value (sig. 2-tailed) |
|------------|-----------------|----|-------------------------|
| RME-EM     | 0.975           | 49 | 0.328                   |
| Conventional | 0.975          |    |                         |

Based on Table 2, it appears that the p-value (sig. 2-tailed) is greater than 0.05, so the achievement of the MCTS of prospective teacher students has a homogeneous variance, so the average difference test used is the t-test.

The hypothesis used to test the difference in the average teaching and learning achievement of student-teacher candidates based on overall learning is as follows.

\( H_0: \mu_1 = \mu_2 \): The achievement of students 'mathematical critical thinking skills who received RME-EM learning was no better than the achievement of students' mathematical critical thinking abilities who received conventional learning.

\( H_1: \mu_1 > \mu_2 \): The achievement of students 'mathematical critical thinking skills who received RME-EM learning was better than the achievement of students' mathematical critical thinking abilities who received conventional learning.
The hypothesis testing criteria used is if the p-value (sig. 2-tailed) is less than 0.05, then $H_0$ is rejected, and in other conditions, $H_0$ is accepted. The recapitulation of the results of the difference in the average achievement of student teaching and learning activities for prospective teacher-students is presented in Table 3 below.

**Table 3. Recapitulation of Student Teacher Candidate Student's MCTS Average Achievement Test Results.**

| Learning  | Mean | $t_{hitung}$ | df | $p$-value (sig. 2-tailed) | Note |
|-----------|------|--------------|----|--------------------------|------|
| RME-EM    | 28.69| 2.904        | 49 | 0.006                    | $H_0$ rejected |
| Conventional | 24.88|              |    |                          |      |

Based on the results of the calculations in Table 3, when viewed from the average value of the two lessons is quite different, the average difference is 3.81. Meanwhile, by using the t-test, the t value is 2.904 with a p-value (sig. 2-tailed) of 0.006. Because the p-value (sig. 2-tailed) is smaller than 0.05, $H_0$ is rejected. So it can be concluded that the achievement of students' mathematical critical thinking skills who receive RME-EM learning is better than the achievement of prospective teacher students' mathematical critical thinking abilities who receive conventional learning.

Based on the test results of the average difference in achievement between prospective teacher students who receive RME-EM learning and prospective teacher students who receive conventional learning, the results show that the achievement of student-teacher training teaching and learning who receive RME-EM learning is significantly better than student-teacher candidates who got conventional learning.

To see the effect of the interaction between student teaching and learning activities and MPK groups, a two-way ANOVA test must be carried out. Before the test is carried out, it is necessary to conduct a normality test for data on the achievement of student MCTS based on learning and MPK groups. If there is data that is not normally distributed in the interaction test, then a description of the effect of the interaction can be seen by analyzing the line graph of the average achievement in both the learning and the MPK groups. If a line intersection is found on the graph, it can be suspected that there is an interaction between the learning and the MPK group, and if there is no line intersection it has the opposite meaning.

The recapitulation of the results of the normality test for the achievement of student learning activities based on learning can be seen in Table 1. The data in the table shows that the high, medium and low MPK groups who get RME-EM learning have data that is normally distributed. Meanwhile, the recapitulation of the results of the homogeneity test of student teaching and learning activities based on learning can be seen in 2. The data in the table shows that all MPK groups for student-teacher candidates who receive both lessons have heterogeneous population variances. Thus, to see whether there is an effect of the interaction between learning (RME-EM and Conventional) and the MPK (High, Medium, and Low) groups on the achievement of student-teacher teaching and learning activities, a two-way ANOVA test is carried out. This test is conducted to determine the role of learning, the MPK group, and the interaction between these two factors.

Before that, we can see the indication through the average line graph. The average line graph is useful for assessing whether there is an interaction effect between variables. However, this graph cannot be used as valid reference material. But it is just a picture. If the lines show no parallel, an interaction effect is suspected. In this case, to see whether there is an effect of the interaction between learning and MPK groups on the achievement of student teaching and learning activities for prospective teacher students, the average line graph analysis is used. The line graph of the average MCTS achievement of student-teacher candidates is presented in the following figure.
Figure 1. The Average Line Graph of Learning and MPK on the Achievement of Student Teacher Teaching and Learning Activities.

Based on Figure 1, the following analysis can be made. The line graph of the average MCTS attainment of prospective teacher students with RME-EM learning is above the average line graph of student teaching and learning activities for prospective teachers with conventional learning. This means that the achievement of the MCTS of prospective teacher students who get RME-EM learning is higher than the achievement of the MCTS of prospective teacher students who get conventional learning. Thus, it can be concluded that learning with RME-EM has a greater influence on the achievement of student-teacher teaching and learning activities compared to conventional learning for each MPK group. In both learning groups, it is seen that the achievement of student MPK student candidates does not change the order of student MPK towards the achievement of MCTS. This means that in the two learning groups, the high MPK group has the greatest influence on the achievement of student teaching and learning activities for prospective teachers compared to the medium and low MPK groups. The medium MPK group with the two lessons had a greater influence on the achievement of student-teacher teaching and learning activities compared to the low MPK group. The line graph of the average MCTS attainment of prospective teacher students who get RME-EM learning and the line graph of the average teaching and learning achievement of prospective teacher students who get Conventional learning look as if they intersect because the two lines meet at one point in low MPK. This raises the suspicion of interaction between learning groups and MPK on the achievement of student-teacher training teaching and learning activities.

Table 4. Recapitulation of ANOVA Calculation Results of Student Learning Activity Learning Centers of Prospective Teachers Based on Learning and MPK.

| MCTS Test | Source | Sum of Squares | df  | Mean Squared | $F_{hitung}$ | p-value (sig. 2-tailed) |
|-----------|--------|----------------|-----|--------------|--------------|-------------------------|
| Learning  | Learning | 121,510       | 1   | 121,510     | 12,368       | 0,001                   |
| MPK       | 535,424 | 267,712       | 2   | 267,712     | 27,249       | 0,000                   |
| Learning* | MPK    | 60,176        | 2   | 30,088      | 3,062        | 0,057                   |
To ensure whether there is an interaction between learning and MPK on the achievement of MCTS, further analyzed using the advanced ANOVA test, namely Tests of Between-Subjects Effects. The recapitulation of the calculation results using the two-way ANOVA test can be seen in Table 4.

Based on Table 4, it can be seen that the p-value (sig. 2-tailed) of learning is smaller than 0.05, namely 0.001 and the p-value (sig. 2-tailed) of MPK of 0,000 is smaller than 0.05. As for the p-value (sig. 2-tailed), the interaction factor (Learning*MPK) of 0.057 is greater than 0.05. Based on the output of learning sources, a p-value (sig. 2-tailed) of 0.001 is obtained where the value is <0.05 so that the hypothesis that we can conclude is that there is an influence on the achievement of student-teacher teaching and learning activities based on learning. Based on the output of MPK sources, a p-value (sig. 2-tailed) of 0,000 is obtained where the value is <0.05 so that the hypothesis that we can conclude is that there is an influence on the achievement of student-teacher training teaching and learning based on MPK. Based on the output of learning resources * MPK, the p-value (sig. 2-tailed) is obtained of 0.057 where the value is> 0.05, so the hypothesis that we can conclude is that there is no interaction between learning and MPK on the achievement of student-teacher training teaching and learning activities.

3.2. Discussion
This section discusses the findings based on the calculation of the research results. Based on the descriptive analysis of the results of the research for the achievement of the MCTS as a whole, it is known that the average achievement of the MCTS of prospective teacher students who get RME-EM learning is better than the average achievement of the MCTS of prospective teacher students who get conventional learning. If it is reviewed based on the results of the inferential research analysis, the same thing is also obtained. This can be seen from the data which shows that the achievement of the MCTS of prospective teacher students who get RME-EM learning is better than the achievement of the MCTS of prospective teacher students who get conventional learning.

Based on the previous description, it can be seen that the application of learning using RME-EM learning has a greater influence on the achievement of student teaching and learning activities for prospective teacher students compared to the application of conventional learning as a whole. The achievement of MCTS for prospective teacher students who get RME-EM learning is significantly better than student-teacher candidates who get conventional learning is possible because the stages of learning RME-EM provide opportunities for prospective teacher students to explore their potential and be actively involved in shaping self-competence. Students' involvement such as the students' interaction in learning process is one example of character education for them to respect the others [17-18]. Thus, the results of this study are in line with the results of previous studies which revealed that RME learning had a positive effect on the achievement of MCTS [19-30].

4. Conclusion
Based on the results of the research and discussion previously described, it can be concluded that in general the achievement of the MCTS of prospective teacher students who get RME-EM learning is better than the achievement of the MCTS of prospective teacher students who get conventional learning. Meanwhile, in terms of the influence of the interaction between learning and MPK, it was found that there was no interaction between the learning group and the MPK group on the achievement of student-teacher training teaching, and learning activities. Overall, through this research result, RME-EM can be a solution for teachers who want to improve their students' MCTS in the classroom.

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