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Effectiveness of the Multiple Representation of Calculus with Mathematica Module to Improve Students' Creative and Critical Thinking Ability

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Abstract.
This research aimed to determine the effect of applying the MRC-Math module using Mathematica software to improve students' creative and critical thinking skills. This research used an experimental design. The sample of this study was 32 students who were taking Calculus courses. The results showed that applying the MRC-Math module improved learning outcomes and students' creative and critical thinking skills. The results of the student response questionnaire showed that the percentage of learning achievement levels with the criteria was excellent. Furthermore, it is necessary to expand the application of this module for learning Calculus courses in several universities in Central Java.

Keywords: MRC-Math, Module, Critical Thinking, Creative Thinking.

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1. Introduction

Problem-solving is not only used in problem-solving but is also used in all aspects of life. In problem-solving, people think creatively in the process of making conclusions (1)(2). Researchers in the field of cognitive psychology found that in addition to having the ability to think processes, humans also can control their behaviour by using productive thinking effectively. Marzano & McTighe (3) put thinking habits into three categories: self-regulation, creative, and critical thinking. Combining two critical and creative thinking skills will form productive thinking skills (4)(5). The ability to think productively can shape students into critical and creative thinkers, increasing their motivation and self-regulated learning (6). In addition, productive thinking also trains a person to regulate his critical and creative thinking skills in solving problems. Thus, internal self-regulation is also required, in addition to the ability to think critically and creatively. Training productive

thinking skills can be done in stages. The first is using creative thinking skills to produce as many alternative problem solutions as possible. The second stage is using critical thinking skills to evaluate and consider the best solutions that can be taken (4). This election will, of course, involve conscious and deliberate self-regulation.

One of the compulsory subjects that need to be mastered by Mathematics Education students is the Calculus subject. This is because this course is a prerequisite course for several other courses. Facts show that many students have passed the Calculus course because they obtained grades above the required ones. However, it is also obtained that many students' mastery of Calculus material is still weak (7). Endahwuri (7) explained that student learning outcomes when using conventional learning were deficient. However, using scaffolding-based learning can improve student learning outcomes in Calculus courses. Common understanding occurs because, generally, lecturers only use symbol representations in explaining Calculus material. Other research that discusses using multiple representations in Calculus learning also does not exist and has not seen its impact on students' productive thinking abilities. When learning Calculus, each student is expected to be able to present every mathematical fact in a variety of different forms. Kalathil & Sherin (8) defines the presentation of various forms of mathematical facts as a process of abstracting mathematical ideas into a form of mathematical representation. The presentation of one mathematical fact/concept into more than one type of representation is called multi-representation. Thus, mathematical problems, especially in Calculus, can also be solved by making several different representations (9). For this reason, media is needed to facilitate students' multi-representation abilities to improve their productive thinking skills. The media that is relevant to these abilities and the principles of the Calculus course is Mathematica.

Learning calculus with many abstract concepts should use software that will help in visualization because in the opinion of Sobel & Maletsky (10) states that visual activities can help students think directly and make them more critical and creative in solving problems in various situations. Software that can be used in learning Calculus courses and is possible to improve productive thinking skills is Wolfram Mathematica. Wolfram Mathematica is computer software developed by Stephen Wolfram based on the visualization of mathematical symbols and algebraic manipulation. Besides being able to be used in mathematics, Wolfram Mathematica software can be used in astronomy, engineering, and science.

2. Method

The MRC-Math module product's effectiveness was tested through quasi-experimental research with One-Group Pretest-Posttest Design (11). The dependent variable was measured as a group before and after the treatment (11)(12). The sample of this research is 32 students who are taking Calculus courses. The test instrument measures students' creative and critical thinking skills when solving problems using Mathematica software. Student response questionnaires were also given to determine the feasibility of using the MRC-Math module in learning. Research data analysis using a paired sample t-test to determine the effectiveness of using the MRC-Math module and N-Gain test to improve students' critical and creative thinking skills.

3. Result and Discussion

Self-regulated learning, creative thinking, and critical thinking skills are indicators of someone having productive thinking skills. Critical thinking ability is the ability to identify, relate, analyze, solve problems, and evaluate. At the same time, someone who is creative thinks if it meets the criteria of flexibility, fluency, sensitivity, originality, and elaboration in thinking. Meanwhile, self-regulated learning includes the ability to plan, be responsive if there is feedback, understand the sources of information needed in solving problems, be able to evaluate the effectiveness of actions, and have self-awareness (1)(2)(3). The results of the analysis of research data show that aspects of critical thinking and creative thinking have the same and a more significant portion than aspects of self-regulated learning. The results showed that the role of creative thinking and critical thinking skills was more dominant in solving a mathematical problem than in self-regulated learning. Figure 1 below shows a visual display of the results of the analysis of students' productive thinking skills in solving mathematical problems.

Furthermore, the research results in implementing MRC-Math on 32 students showed that students' productive thinking skills through using MRC-Math were better than before using MRC-Math. An experimental design was carried out to test this product's effectiveness. After treatment is given to the group, the scores before (pre-test) and after the treatment (post-test) are compared with paired sample t-test. Based on the analysis results using SPSS, the value of sig. = .001 $<$ .05. So, it can be concluded that students' average productive thinking ability through MRC-Math is better than before using it. Table 1 shows descriptive statistics of student learning outcomes representing their productive thinking abilities, especially creative and critical thinking skills.

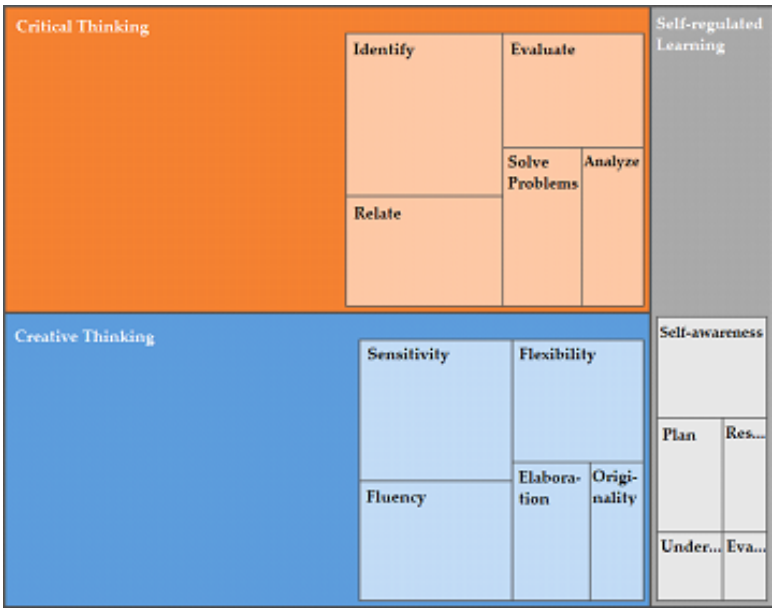

Figure 1: Hierarchical Diagram of Productive Thinking.

TABLE 1: Descriptive Statistics.

Measures	Pre-test	Post-test
Number of students	32	32
Standard deviations	5.270	7.084
Variance	27.770	50.177
Mean	75.312	92.375
Individual learning completeness	17	30
Classical learning completeness	53.12%	93.75%

Based on the summary in Table 1, the data obtained from individual and class classical learning outcomes results after using MRC-Math. Students are said to have met the individual completeness score if they reach a score of 70 following the Minimum Completeness Criteria (MCC), which is a B value. The results showed that 30 students completed individual learning mastery among 32 students after using the MRC-Math module. Meanwhile, during the pre-test before the module was used, only 17 students completed of 32 students. This shows that the percentage of classical learning completeness after using the MRC-Math module is 93.75%.

The N-Gain test is carried out to see how much increases students' productive thinking skills using MRC-Math. The data used are pre-test and post-test value data. Table 2 shows increased students' critical and creative thinking skills in solving mathematical problems. The improvement category is the medium category. This shows that using MRC-Math is better for improving students' critical and creative thinking skills (11).

Table 2: N-Gain of Students' Productive Thinking Skills.

Critical thinking	N- Gain	Interpretation		Creative Thinking	N- Gain	Interpretation
Identify	0.45	Medium		Flexibility	0.45	Medium
Connect	0.55	Medium		Smoothness	0.45	Medium
Analyze	0.35	Medium		Originality	0.45	Medium
Solve problems and evaluate	0.45	Medium		Sensitivity and elaboration	0.50	Medium
Average N-Gain	0.45	Medium		Average N-Gain	0.46	Medium

Furthermore, a student response questionnaire on the application of learning using MRC-Math was given to 32 students to assess its feasibility. Student response questionnaires are given after learning is complete. The results of the student response questionnaire show that the percentage of achievement level is 89.8%, which is included in the excellent criteria and deserves to be used (11)(12).

4. Conclusion

The results showed that using the Mathematica software-based MRC-Math module effectively improved students' creative and critical thinking skills. This is reinforced by the number of students who have mastery of learning and student responses in using the Mathematica software-based MRC-Math module on excellent criteria.

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References

[1] Torrance EP. Creativity. What research says to the teacher, series, no. 28.

[2] Marzano RJ. A different kind of classroom: Teaching with dimensions of learning. Alexandria, VA: Association for Supervision and Curriculum Development; 1992.

[3] Marzano RJ, Pickering D, McTighe J. Assessing student outcomes: Performance assessment using the dimensions of learning model. Alexandria, VA: Association for Supervision and Curriculum Development; 1993.

[4] ThinkX. Productive thinking fundamental: Participant workbook. Kanada: ThinkX Intellectual Capital IP Inc.; 2012.

[5] Hyman R.T. Ways of teaching. Philadelphia, New York, Toronto: J. B. Lippincott Co.; 1974.

[6] Harrington M. Australian curriculum, assessment, and reporting authority bill 2008. Parliamentary Library; 2008 Nov 24.

[7] Endahwuri D. Pengembangan perangkat pembelajaran mata kuliah Kalkulus Lanjut 1 dengan scaffolding berbasis kemampuan pemecahan masalah. Media Penelitian Pendidikan: Jurnal Penelitian dalam Bidang Pendidikan dan Pengajaran. 2015;9.

[8] Kalathil RR, Sherin MG. Role of students' representations in the mathematics classroom. International Conference of the Learning Sciences. 2013:39–40.

[9] Gagatsis A, Elia I. The effects of different modes of representation on mathematical problem solving. International Group for the Psychology of Mathematics Education. 2004.

[10] Sobel Max A, Maletsky E M. Mengajar matematika. Jakarta: Penerbit Erlangga; 2003.

[11] Unaradjan DD. Quantitative research methods. Jakarta: Atma Jaya Unika Publisher Jakarta; 2019.

[12] Kusumastuti A, Khoiron AM, Achmadi TA. Metode penelitian kuantitatif. Jogjakarta: Deepublish; 2020.