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Research article

The Validity of a Multiple Representation of Calculus With Mathematica Learning Tool for Improving Students' Productive Thinking Abilities

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Abstract.

In the era of the fourth industrial revolution, productive thinking skills are in high demand. Creative thinking, critical thinking, and independent learning are all part of productive thinking skills. A person's ability to solve a problem with various alternatives can be measured in a range of ways, and productive thinking is linked to these abilities. Wolfram Mathematica is a cutting-edge technology that can be used to solve and visualize a wide range of mathematical problems. The purpose of this study was to develop a multiple representation of calculus with Mathematica (MRC-Math) learning tool to improve students' productive thinking skills. After developing the MRC-Math learning tool, the experts validated the device. Based on the results of the validation, several improvements were made to the learning device, and then the tool was re-validated. The final validation result showed that the MRC-Math learning tool has a high level of validity.

Keywords: validaty, MRC-MATH, multiple representation, calculus, productive thinking ability

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1. Introduction

Mathematics is given from basic to higher education to equip students in critical, creative thinking and independence in proposing and solving problems. However, at the LPTK level, in general, the quality is not guaranteed in producing competent teacher candidates. The learning process is still product-oriented and memorization, students often choose ideas from lecturers, not from the ideas they produce. Productive thinking seeks to combine and balance two ways of thinking creatively and critically [1]. Students must be critical, creative and adaptable with motivation, confidence, and skills to use critical and creative thinking intentionally [2]. Therefore, the ability to think productively which is a combination of critical and creative thinking as well as the ability to self-regulate is very necessary.

The principle of productive thinking separates two creative, critical thinking at the same time. The first step is to think creatively to produce as many choices as possible, followed by critical thinking to evaluate and choose the best option [1]. Productive thinking has a relationship with multiple representations. [3] which states that students who have high independence can show various representations while students with low mathematical abilities only show one representation in solving problems. A similar study conducted by [4] regarding the analysis of multiple profiles of student representation in the Real Analysis course based on the principles of David Ausubel's learning theory also showed relatively similar results. Multiple representation research can be developed by making learning tools oriented towards increasing students' productive thinking. This is very important because students have a lack of showing various representational abilities in solving mathematical problems.

Calculus is a fundamental material that must be mastered by students and is a prerequisite for several courses in the next semester [5]. Although many students graduate, in fact the ability to master the Calculus material by the students concerned is still weak. [5] stated that student learning outcomes in Calculus using scaffolding-based learning tools were better than conventional learning. However, research has not touched on multi-representation to improve students' productive thinking skills. It should be emphasized that in calculus, students are expected to be able to express ideas in various ways. [6] defines that everything in the form of student ideas is called representation. Representations of more than one type are said to be multiple representations. Each problem can be solved by presenting a different representation [7, 9-10]. For this reason, we need media that are in accordance with the ability of multiple representations to improve students' productive thinking. The media that is relevant to these abilities and the principles of the Calculus course is Mathematica. Mathematica is software based on symbol visualization and algebraic manipulation.

Through this research, it will help to solve the problems of the cultural marginalized, namely by making the critical awareness of students as social capital for transformation so that it can encourage productive actions of marginalized communities. Seeing the problems above, it indicates the need for learning tools that can accommodate productive thinking in students. The MRC-MATH (Multiple Representation of Calculus with Mathematica) device was developed to improve students' productive thinking skills. The specific purpose of this research is to develop a valid, effective and practical MRC-Math learning tool used to improve students' productive thinking skills.

2. Method

This includes research and [8] explained that the purpose of this study was to be able to produce certain poduk and test the effectiveness of the product in order to be useful in the wider community. This research is part of an R&D research step developed by Borg and Gall.

This research was conducted in the Mathematics Education Study Program at Universities in Semarang City (UPGRIS, UNISSULA and UIN Walisongo). The selection of this location is based on the following considerations: 1) ease of communication between researchers and students and researchers with lecturers in several universities in Central Java, and 2) has been conducted research on MRC-Math (Multiple Representation of Calculus with Mathematica) submitted.

Validation data on MRC-Math devices is analyzed descriptively. The average score (p) of the results of the assessment of the three validators is adjusted to the criteria in Table 1.

TABLE 1: MRC-Math Device Validity Assessment Criteria.

Score interval	Assessment Criteria	Information
$4.00 \leq p < 5.00$	Very valid	Can be used without revision
$3.00 \leq p < 4.00$	Valid	Can be used with a little revision
$2.00 \leq p < 3.00$	Keep	Can be used with many revisions
$1.00 \leq p < 2.00$	Less	Unusable

Whereas, in order to make an assessment on content validity, expert judgment in the form of quantitative analysis is applied. Quantitative analysis of the content validity using Aiken's V. Data were obtained from three expert judgements.

$$V = \frac{\sum s}{n(c-1)}$$

s = r-lo

r = the value given by expert

lo = lowest validity score

c = highest validity score

n = number of experts who gave the score

If $V \geq 0.75$ then it is said to be valid.

3. Results and Discussions

The first stage in this research is the development of the MRC-Math device (Figure 1-3).

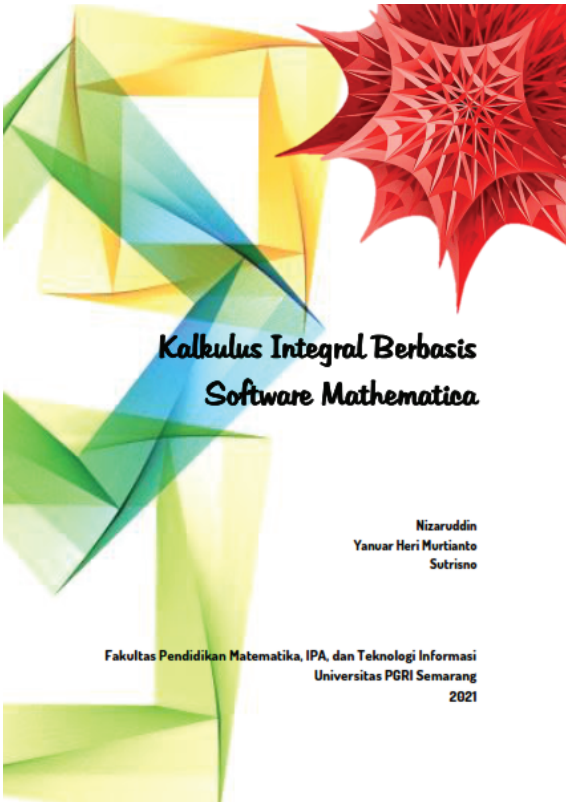

Figure 1: MRC-Math Device Cover.

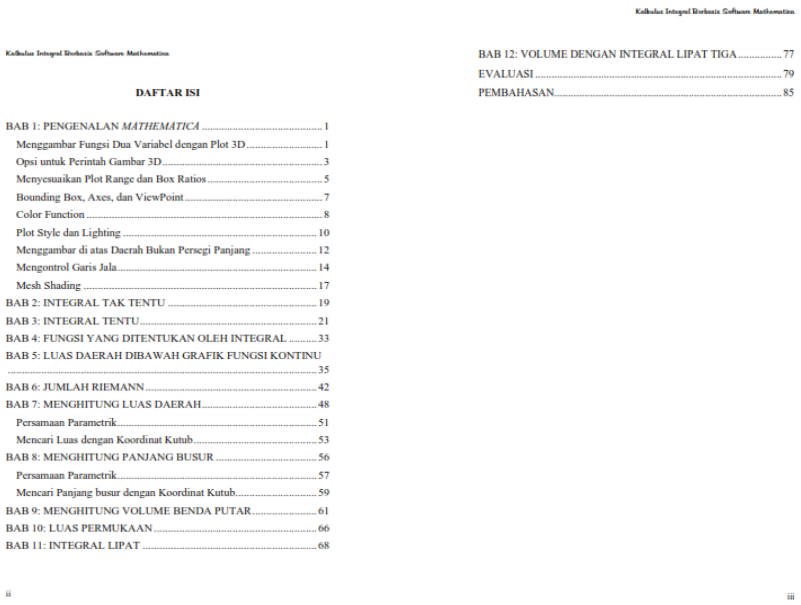

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Figure 2: MRC-Math Device Table of Contents.

Prototypes of MRC-Math devices that have been developed are then was validated by expert judgement. The validator of this study is presented in Table 2.

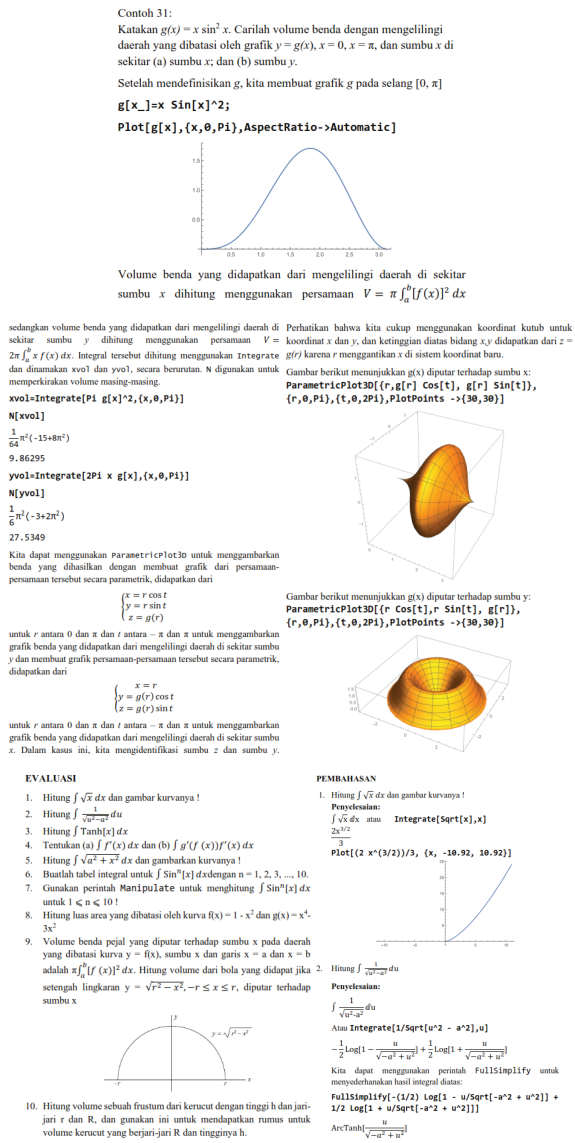

Figure 3: Examples of Representations on MRC-Math Devices.

TABLE 2: MRC-Math Device Validator.

No.	Validator Name	Assessment Results
1	Dr. Imam Kusmaryono, M.Pd.	Can be used with a littlerevision. Slight revisions to the writing of the words Remember -> remember (p. 23), below -> below (p. 35, 107), When -> when (p. Add a bibliography.
2	Mujiasih, S.Pd., M.Pd.	Can be used without revision
3	Dr. Muhtarom, M.Pd.	Can be used without revision

Validation results become revision material to THE MRC-Math device. In addition to getting improvement advice, validators also provide quantitative assessments and the results are analyzed descriptively as presented in Table 3.

Description:

Table 3: Validator Assessment on MRC-Math Devices.

Assessment Indicator	Assessment Item	V 1	V 2	V 3	V	Criterion
ISI ELIGIBILITY						
Accuracy of Materials	Accuracy of material concepts	4	5	5	0,917	Valid
	Accuracy of examples and cases	4	4	4	0,750	Valid
	Accuracy of images, diagrams, and illustrations	4	5	4	0,833	Valid
	Accuracy of terms	4	5	4	0,833	Valid
Material Update	Images, diagrams and illustrations are clear	5	5	4	0,917	Valid
	Use relevant examples and cases	4	4	5	0,833	Valid
	Encourage curiosity	3	5	5	0,833	Valid
	Creating productive thinking skills	3	5	4	0,750	Valid
PRESENTATION ELIGIBILITY						
Presentation Techniques	Each section is clearly identified.	4	4	4	0,750	Valid
	The material of each activity is relevant to the purpose of	4	5	4	0,833	Valid
	Clear and interesting numbering system	4	5	4	0,833	Valid
	Balanced text and illustrations	4	5	4	0,833	Valid
	Font type and size, as well as decent spaces	5	5	5	1,000	Valid
	Physical size for students	5	5	4	0,917	Valid
	The level of visual teaching book	4	4	4	0,750	Valid
Coherence and Traceness of The Flow of Thought	Linking between learning activities	3	5	4	0,750	Valid
	The wholeness of meaning in learning activities	3	4	4	0,667	Valid
LANGUAGE ELIGIBILITY						
Communicative	Accuracy of sentence structure	4	5	4	0,833	Valid
	Sentence effectiveness	4	5	4	0,833	Valid
	The term ”filthy”	4	5	5	0,917	Valid
	Understanding of messages or information	3	4	5	0,750	Valid
	Ability to motivate learners.	3	5	5	0,833	Valid
Conformity with student development	Conformity with the intellectual development of students	4	5	4	0,833	Valid
	Compatibility with the student’s level of emotional development	4	5	4	0,833	Valid
Conformity with Language Rules	Grammatical accuracy	3	5	5	0,833	Valid
	Spelling accuracy	4	5	4	0,833	Valid
	Using good and correct Indonesian	4	5	5	0,917	Valid
	Using communicative and effective language	4	5	5	0,917	Valid
Validation Results		SR	TR	TR		
Sum		108	134	122		
Average		3,86	4,79	4.36	0,833	Valid
Total Average		4.33				
Assessment Criteria		Very valid				

SR: Can be used with a little revision

TR: Can be used without revisionBased on Table 3 it can be concluded that the average assessment of validators, MRC-Math devices are veryvalid. While Aiken V obtained V $\geq$ 0.75 then it is said to be valid.

4. Conclusion

Contingent on the results of the validation, several improvements were made to the learning device, then the results of these improvements were re-validated. The final validation result shows that the MRC-Math learning tool is valid.

5. Authors' Contributions

The results of this study contribute to the development of various learning tools in calculus courses.

Acknowledgments

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