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Teaching Material Topology: Development in Metacognitive Ability

Teaching Material Topology: Development in Metacognitive Ability

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Abstract. Technology integration in the learning process is needed in the technological era as a form of development of teaching materials that can improve students' metacognitive abilities. This study aims to develop valid, practical, and effective topology teaching materials based on students' metacognitive abilities. Research and development follow the steps of developing a 4-D model that includes Define, Design, Develop, and Disseminate. The results showed that topology teaching materials met the validity criteria of 82.50%. Practicality is 82.92% in the small scale test and field test with practicality is 85.02%. Then teaching materials meet the effectiveness with limited trials of 83.33% and field tests of 87.5%. Based on these results, topology teaching materials can be used as learning resources in measuring metacognitive abilities.

1. Introduction

The era of digital technology is important for mathematics [1,2]. Mathematics is an important subject to be learned by all students [3]. Mathematics is a branch of science that plays an important role in education [4]. The role of mathematics influences learning experiences [5], and can be optimized with curriculum support that encourages student flexibility, fluency, novelty, and metacognitive elaboration [6]. Mathematic has an important role because it is the basis of logic or reasoning and quantitative; using used in other lessons [7]. The facts show that mathematics is the branch of science is in a high position, consequently, mathematics becomes the basis of a person in thinking [8]. Education is now entering the challenges, where learning is focused on students' abilities and learning skills [9]. However, learning mathematics is still considered difficult by some students [10].

Factors that influence learning success, besides depending on the learning approach used are also influenced by the teaching materials used [7, 8]. Teaching materials and learning resources are seen as important factors in determining the success of curriculum implementation. One of many things development by the government in the field of education in Indonesia is the 2013 curriculum [13].

However, in reality in the field, learning tools have not emphasized the students' metacognitive abilities [14], causing the students to have low metacognitive abilities [15] addition, based on observations of

topology lectures, most mathematics students at the Universitas PGRI Madiun have difficulty in solving problems, resulting in non-optimal metacognitive abilities, and decision making [16]. This is because everyone has diverse experiences with abstract ideas [17] so that each student has different difficulties in solving abstract topological problems [18].

The importance of metacognitive cognition concerning how a person is aware of his thought processes [19], experience in honing analytical skills, critical reasoning, and problem-solving abilities [18].Therefore, it is necessary to innovate the development of teaching materials that can facilitate student metacognition [20], and be able to create solutions in solving problems that are rapidly changing in the future, as well as being the key in creating generations the successor of a nation with global competitiveness to become a reference in the future Indonesian education process.

Based on previous research, the development of instructional materials oriented to the meta-technician of successful students was developed with the contribution of excellent effectiveness [21], learning that happened successfully [22] can be used as an effective teaching material from strategies selected by O'Neil and Abedi [23], the quality of textbooks influences students' mathematical knowledge [24, 25].

So far there have been no teaching materials that help students understand the concept of topology, the researchers developed a teaching material that will help students understand the concept of topology and stimulate students' metacognitive abilities. Therefore, this study aims to teach topology materials that are valid, practical, and effective based on the metacognitive abilities of the lesson plans, student worksheets, and learning outcomes test.

2. Methods

This study aims to develop feasible topological teaching materials to improve metacognitive abilities. This study uses a 4-D model[26]. The procedure of this research can be seen in the following figure.

Figure 1. Research and Development Steps

Based on the analysis of the needs and objectives of the research, this research would not be interesting and beneficial if it did not see the effectiveness of the product, while the 4D phase in the study is described as follows:

2.1. Define

The defining stage includes the analysis of potential problems, at this stage, the researcher looks for data about potential problems related to the place and subject of the study. Information gathering is done by observing various aspects needed to be related to the development of teaching materials. After analyzing the potential and problems, observations, and interviews, then the researcher needs to formulate learning objectives. This was done to limit researchers from deviating from their original goals.

2.2 Design

At this stage, researchers design topology teaching materials to facilitate students' cognitive abilities. The design of topology teaching materials is adjusted to the objectives and required outcomes. Furthermore, the preparation of the structure of topology teaching material structure is based on student competencies. The instruments used and needed in this study include the instrument validation sheet, the validation sheet of teaching materials to measure the level of validity of the developed media.

2.3 Develop

The next step is to develop topology teaching materials. The aim is as a product to be tested for eligibility, practicality, and effectiveness. The validity data of teaching materials were passed through the validation sheet Student Worksheet, the validation sheet Lesson Plan, and Learning Outcomes Test. The validation sheet uses a Likert scale with scores seen in the following table.

Table 1. The scoring

Category	Score
Very Good	5
Good	4
Pretty Good	3
Less Good	2
Good	1

Then, the validity criteria will be validated with the validity criteria as follows:

Table 2. Validity Criteria Validity

Criteria Validity	Level
85,01% - 100,00%	Very valid, can be used without revision
70,01% - 85,00%	Quite valid, can be used but needs to be revised small
50,01% - 70,00%	less valid, it is recommended not to use because it needs a major revision
01,00% - 50,00%	Not valid, may not be used

Product trials consist of two stages, namely limited trials and field trials. In the limited trial involving two lecturers and 6 students while in the field trial involving two lecturers and 32 students. Data on the practicality of teaching materials were obtained through a student response questionnaire. The practicality sheet uses a Likert scale which can be shown in the following table 3.

Table 3. Scoring

Category	Score
Strongly Agree	5
Agree	4
Neutral	3
Disagree	2
Strongly Disagree	1

The percentage of the student assessment results will then be calculated in percentage to determine the practicality of topology teaching materials using formulas$P = \frac{A}{B} \times 100\%$ (P = Percentage of student responses, A = Total number of scores obtained, B = Ideal score).

Data on the effectiveness of teaching materials is obtained from the results of student learning outcomes tests after participating in learning with teaching materials. The indicator of the effectiveness of teaching materials is ≥75% of students' grades above the minimal learning objective reaching. Students are said to have finished learning if a minimum of 75% of students who classically get a minimum score of 75. Furthermore, the percentage of effectiveness results are analyzed according to the effectiveness criteria guidelines.

Table 4. Effectiveness Criteria

Percentage (%)	Level of Effectiveness
90 – 100	Very Effective
80 – 89	Effective
70 – 79	Fairly Effective
60 – 69	Less Effective
<60	Ineffective

2. 4 Disseminate

At this stage, topology teaching materials are distributed as teaching materials that can be used in learning topology courses.

3. Results And Discussion

Based on the development steps that have been carried out, the research and the resulting product is in the form of the lesson plan and student worksheets as teaching materials to facilitate students' Metacognitive abilities. The results and discussion of research and development are explained as follows.

3.1 Define

At the stage of potential and problem analysis carried out by observing the learning process and the availability of teaching materials in topology courses. Based on observations obtained that most of the students are more likely to memorize concepts than understand the parts of the concept in solving mathematical problems. This can be seen from the ability of students to understand and master the material. Based on this analysis, the lecturer provides learning that trains students to be able to solve problems and be able to organize their thoughts in decision making.

3.2 Design

The design stage is used as a reference for developing the developed topology teaching materials. At this stage, the preparation of instruments used and needed in research is carried out. Instruments and data collection techniques compiled by researchers are instrument validation sheets, textbook validation sheets, student response questionnaire sheets, learning achievement test questions sheets and learning achievement test validation sheets. Also, at this stage instruments were prepared to measure the effectiveness of teaching materials consisting of Lesson Plan, Student Worksheet, and Learning Outcomes Test student validation sheets. Furthermore, the product produced at the defining stage is called draft 1.

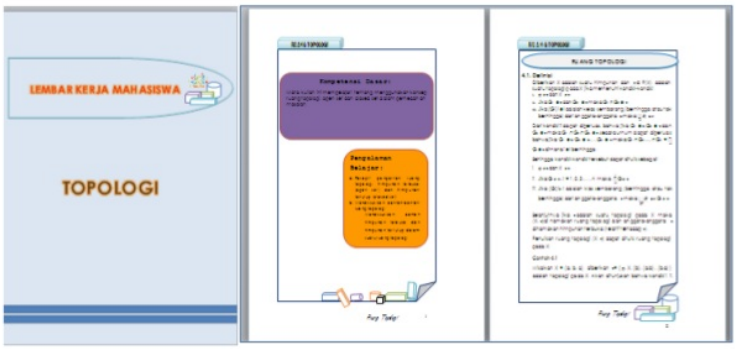


Figure 2. Draft 1 Students Worksheet Development Results

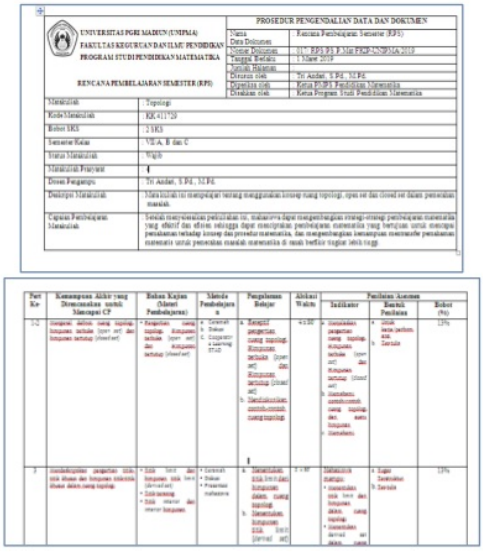


Figure 3. Draft 1 Lesson Plan Development Results

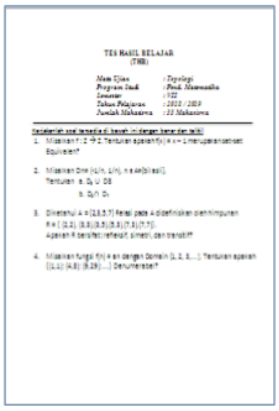


Figure 4. Draft 1 Test Development Results

The product that has been produced is taken to the validator/expert to determine validity. The average score from the expert assessment results is used to determine the validity of the product. Based on the results of the analysis it was found that learning using teaching materials obtained an average score of 82.50. Products were revised based on input from both validators. The revised product is referred to as draft 2.

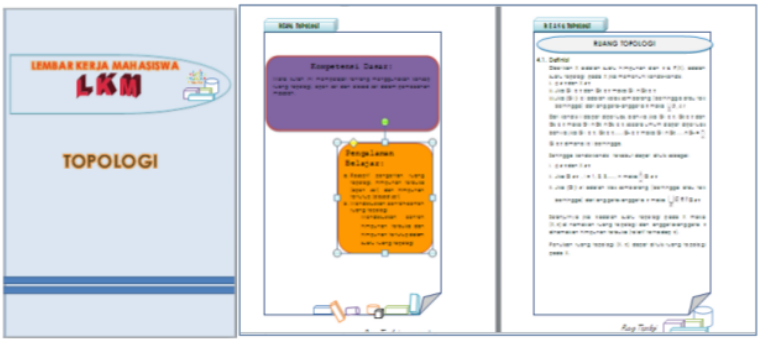


Figure 5. Draft 2 Students Worksheet Development Results

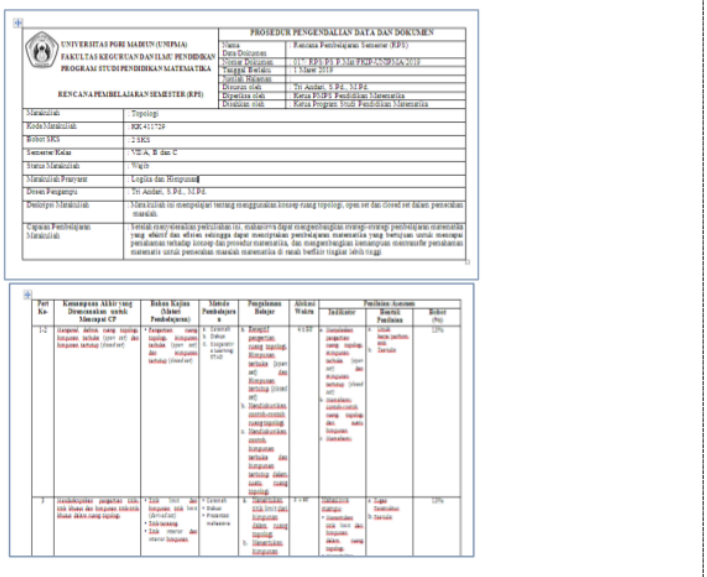


Figure 6. Draft 2 Lesson Plan Development Results

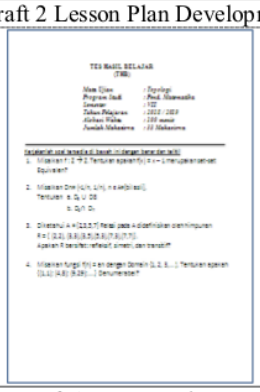


Figure 7. Draft 2 Test Development Results

3.3 Develop

After the product is declared valid/feasible by the expert, the next step is to provide the product in a limited trial. The limited trial involved two lecturers and 6 semester VII students of the Mathematics Education study program at PGRI Madiun University. Student Worksheet draft 2 results were given to 6 students in a limited trial to determine the Student Worksheets readability test that was made. After conducting learning using Student Worksheet are asked to fill in the questionnaire response. Based on the analysis results, the following data are obtained:

Table 5. Small-scale Trials

Indicator	No. Item	Percentage	Average	Criteria
Benefit in the use of teaching materials (Interest, interest, satisfaction, effectiveness)	1	82, 60 %	84,99 %	Good
	2	85,5 %		
	3	87,75 %		
	4	82,7 %		
	5	84,00 %		
Ease of using teaching materials	6	77,7 %		
	7	79,23 %		
	8	75,5 %		
	9	87,54 %		
	10	86,33 %		
			81,26 %	Good
Average of all indicators			**83,12 %**	**Good**

Based on Table 5, it appears that the results of the trial obtained a practical percentage of 82.92%. In this study, teaching material is declared practical if ≥ 70% of students classically give a positive response [27]. In line with this, [28] also believes that learning media is practical if the game media can be used without revision or revision, so the teaching material is valid from the validity test conducted by validating the experts through the validation sheet instrument [29].

Table 6. Large-scale Test

Indicator	No. Item	Percentage	Average	Criteria
Benefit in the use of teaching materials (Interest, interest, satisfaction, effectiveness)	1	85, 60 %	84,86 %	Good
	2	86,50 %		
	3	77,75 %		
	4	85,70 %		
	5	89,45 %		
Ease of using teaching materials	6	86,97 %	85,14 %	Good
	7	82,75 %		
	8	79,5 %		
	9	88,74 %		
	10	87,73 %		
Average of all indicators			85,02 %	Good

Based on Table 6, the results of the analysis showed that the practicality percentage was 85.02%. Next is the effectiveness test. In this test, it is tested on students in topology learning. The data can be seen in the following table:

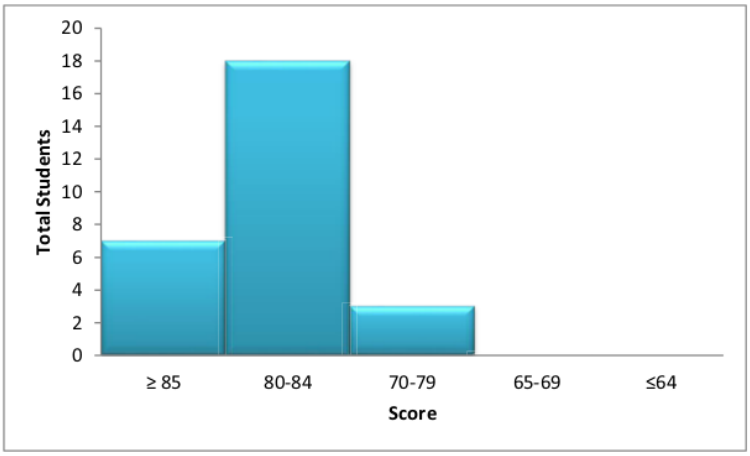
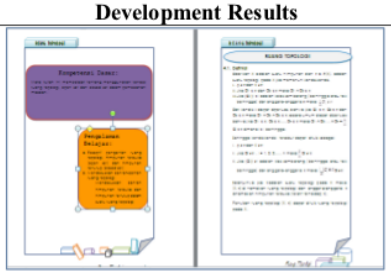
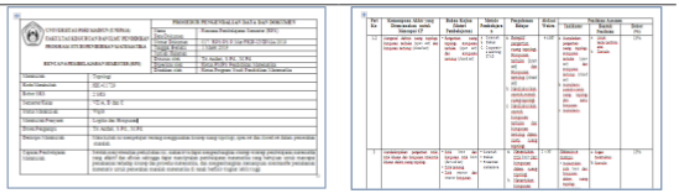


Figure 8. Effectiveness of Teaching Materials

Based on Figure 8, it can be concluded that the teaching material is effective with the effectiveness of the learning achievement test obtaining an average learning outcome of 80.37 and completeness of learning by 87.5%. the following are the final results of developing products that are ready to be given to students at the disseminate stage.

Product	Development Results
Students Worksheet	
Lesson Plan	

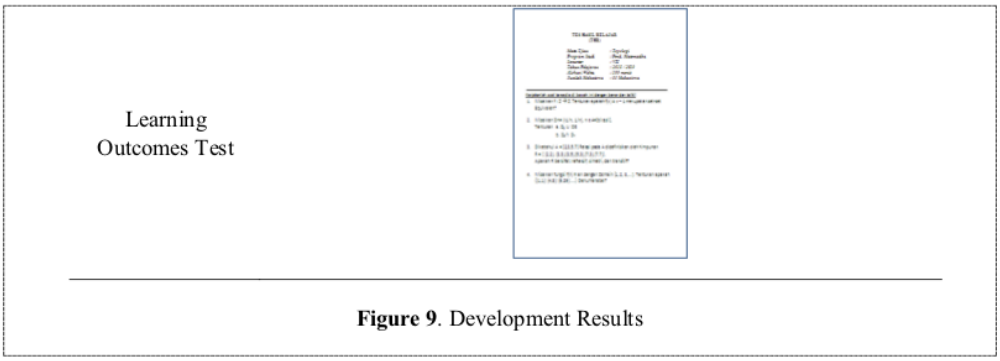


Figure 9. Development Results

3.4 Disseminate

At this stage, researchers disseminate this teaching material to all students in topology courses. The aim is to facilitate the Metacognitive abilities of students. Teaching material developed is a part that needs to be provided in the learning process [18]. Each will do the teaching and learning process a teacher must prepare teaching materials properly. The teaching materials needed in learning can be in the form of Lesson Plan, Student Worksheet, and THB. With the topology teaching materials based on metacognitive abilities, students can learn actively because this pursuit focuses on student activities such as asking questions and solving problems. This is in line with research that learning with a metacognitive approach focuses on student activities; helps and guides students if there are difficulties, and helps students develop self-concepts of what they do when learning mathematics [30].

The metacognitive abilities of each individual are different, so the results of this development are to know and monitor one's thinking activities so that the metacognitive processes of each person will differ according to their abilities [31].

The quality of products developed in research is determined based on three aspects, namely validity, practicality, and effectiveness. Judging from the validity aspects of Lesson Plan, Student Worksheet, and Learning Outcomes Test as a whole the assessment is given by experts or experts namely teaching materials that are already appropriate to use, with an average of 82.50. In terms of practicality in field trials of 82.92% and the percentage of practicality in field trials of 85.02%. As for the effectiveness aspect, the results obtained at the time of the trial were limited to 83.33% and in the field trials, 87.5% of students completed or reached the minimal learning objective reaching.

In a study conducted by [29]states that learning media is valid from the validity test conducted by validating the experts through the validation sheet instrument. The results of expert validation are presented in the following table:

Table 7. The results of expert validation

Validation to	Score	Eligibility Level
1	79	Eligible
2	86	Eligible

After the product is declared valid/feasible by the expert, the next step is to provide the product in a limited trial. The limited trial involved two lecturers and 6 semester VII students of the mathematics education study program at PGRI Madiun University. Student worksheet draft 2 results were given to 6 students in a limited trial to determine the Student worksheet readability test that was made. After conducting learning using students worksheet are asked to fill in the questionnaire response. Based on the results of the analysis it was found that learning using teaching materials obtained a practical percentage of 82.92%. In this study, teaching material is declared practical if ≥ 70% of students classically give a positive response. In line with this, [28] also believes that learning media is practical if the game media can be used without revision or revision. This agrees with [32] statement that "*Practical is materials that teachers consider the materials to be usable and that it is easy for teachers and students to use ...*". Based on the results obtained, it can be concluded that learning using teaching materials has met the practicality criteria

To determine the effectiveness of teaching materials obtained based on learning achievement tests using teaching materials with an average learning outcome of 79.66 and completeness of learning by 83.33%. The results obtained are supported by student responses where students are more active when learning to use teaching materials based on metacognitive abilities. Learning requires students to be directly involved in learning activities that require students to solve problems related to the material being studied so that students will more easily understand the material. This is in line with [33], which states that learning based on metacognitive abilities has a positive influence on students' problem-solving abilities.

In this study, the percentage of mastery learning is at least 75% of all students. So it can be concluded that the results of learning achievement tests in limited trials meet the effectiveness criteria. Based on the results of practicality and effectiveness is limited trials, the teaching material is declared suitable for use in field trials.

The field trial involved two lecturers and 32 students. Based on the analysis results obtained that the practicality percentage of 85.02%. Based on the results obtained, it can be concluded that learning using teaching materials has met the practicality criteria. While the level of effectiveness based on learning outcomes tests obtained an average learning outcome of 80.37 and mastery learning by 87.5%. The learning outcomes use topology teaching materials as follows:

Table 8. The learning outcomes

Value	**Number of Students**
≥ 85	7
80-84	18
70-79	3
65-69	-
≤64	-
Total	**32**

Based on the results of the analysis shows that teaching materials can be said to be practical and effective. As proof that the teaching material is said to be the results obtained from limited trials and field trials obtain good results. Teaching material is a part that needs to be provided in the learning process [18]. Each will do the teaching and learning process a teacher must prepare teaching materials properly. The teaching materials needed in learning can be in the form of the Lesson Plan, Student Worksheet, and Learning Outcomes Test.

How important is the availability of learning resources so that a lecturer must be able to develop teaching materials that are in accordance with good criteria. According to the *Association for Educational*

Communication and Technology (AECT, 1977) in [34], learning resources are all things or resources that can be utilized by teachers, both separately and in a combined form, for the benefit of teaching and learning to increase the effectiveness and efficiency of learning.

Based on reality in the field, most students find it difficult to understand the material in topology courses. To be able to help students easily understand and master the material, the lecturer provides learning resources. One learning cycle that trains students to be able to solve problems and be able to manage their thoughts in decision making is by developing topology teaching materials based on students' metacognitive abilities. Teaching materials are all forms of materials that can be used to help the teacher/instructor in carrying out teaching and learning activities in class. The intended teaching material can usually be in the form of written teaching materials and unwritten teaching materials. (*National Center for Vocational Education Research Ltd. / National Center for Competency-Based Training*) [34].

With the topology teaching materials based on metacognitive abilities, students can learn actively because this pursuit focuses on student activities such as asking questions and solving problems. This is in line with the opinion [30] which states that learning with a metacognitive approach focuses on student activities; helps and guides students if there are difficulties, and helps students develop self-concepts of what they do when studying mathematics.

The metacognitive abilities of each individual are different. The different abilities in learning mathematics allow for differences in metacognitive processes performed by students in the learning process. This is in accordance with the opinion [31] that metacognition as the ability to know and monitor one's thinking activities so that the metacognition process of each person will differ according to their abilities. Furthermore [35] states that "*Metacognition is the knowledge and evaluate One's thinking*". It means that metacognition is a person's skill in organizing and organizing and evaluating thought processes.

Metacognitive plays a critical role in successful learning [36]. According to toCountinho (2007) in [37], states that there is a positive relationship between academic achievement and metacognition. Students who have good metacognition skills will show good academic performance compared to students who have low metacognitive abilities. This is in accordance with the results of the study [38] with the title "The effect of metacognitive abilities on student academic achievement in basic programming courses" with the results of the study showing that metacognitive abilities have a positive and significant effect on academic achievement in programming subjects. Metacognitive skills can help develop good thinking management skills so that they show good academic performance compared to students who have low metacognitive abilities.

Based on the results of research and discussion and supported by research studies from experts, the development of topology teaching materials based on the metacognitive abilities of students is appropriate to be used in Topology courses.

4. Conclusions and Recommendations

Product quality development results in the study are determined based on three aspects, namely the aspects of validity, aspects of practicality, and aspects of effectiveness. Judging from the validity aspects of Lesson Plan, Student Worksheet, and Learning Outcomes Test as a whole the assessment is given by experts or experts that are teaching materials that are appropriate to use, with an average of 82.50%. In terms of practicality in small scale trials of 85.33% and the percentage of practicality in field trials of 85.02%. As for the effectiveness aspect, the results obtained at the time of the trial were limited to 83.33% and in the field trials, 87.5% of students completed or reached the minimal learning objective reaching.

This teaching material can be used in the process of learning mathematics, but this teaching material can only be presented in topology courses to support the metacognitive students, so it is expected to be developed in other materials.

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