Suska Journal of Mathematics Education
(p-ISSN: 2477-4758|e-ISSN: 2540-9670)
Vol. 8, No. 2, 2022, hal. 139-150

Development of Discovery Model-Based Learning Tool Using Cabri 3D Interactive Multimedia to Improve Students' Mathematics Communication Ability

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ABSTRACT. This study aims to develop learning tools using discovery learning models assisted by the 3D Cabri application to improve students' mathematical communication ability. This research is a development research using the 4-D Thiagarajan model which consists of 4 stages, namely define, design, develop and dissemination. The research subjects were students of SMP Negeri 5 Aceh Tengah class IX. The research instruments used were the lesson plan validation sheet, the student worksheet validation sheet, and mathematical communication ability test validation sheets, teacher response questionnaires and student response questionnaires. Data analysis techniques are validity analysis, practicality analysis and effectiveness analysis. Based on the test results, the average assessment of the three aspects of the lesson plan is 4.01 with valid criteria. The average assessment of the three aspects of the student worksheet is 4.05 with valid criteria. The average score on the three aspects of the mathematical communication test is 3.65 with valid criteria. The practicality analysis uses a teacher response questionnaire with an average practicality score of 85% and is included in the very practical category. Based on the results of the students' response questionnaire data analysis, it was concluded that students had a positive response, namely 92.12% of the components and learning activities so that they showed effective results. The data on the effectiveness of learning outcomes were obtained from the pre-test and post-test scores of students' cognitive in learning using n-gain and the average value of the results of increasing mathematical communication ability was 0.70 which stated that mathematical communication ability increased in the medium category. The validation and testing of learning tools show that the learning tools meet the criteria for the learning tools developed, referring to being valid, practical, and effective.

Keywords: cabri 3D, development, discovery learning, learning tools, mathematical communication.

INTRODUCTION

Learning mathematics is considered to be a subject that is very deserving of attention and is very significant in the realm of education. The importance of mathematics can train students to be able to think logically, analytically, systematically, critically, and creatively. One is demonstrated through the use of mathematics that, with the right procedures, desired results are possible. The process of reasoning is aided and the intellectual framework is strengthened by the steps taken to solve mathematical problems. Furthermore, it has been proven that completing mathematics problems benefits the brain by facilitating cognitive processes like decision-making (Kasmin, Othman, & Ahmad, 2019).

Physical and mental activity are two characteristics of learning activities. The two components must be interconnected in order for learning to take place. Therefore, in order for students to actively think, they must be given the chance to seek out their own experiences and be able to develop all of their personal aspects. Additionally, for students to reach their full potential, they must be more active. This can be developed with the development of learning tools using

DOI:http://dx.doi.org/10.24014/sjme.v8i2.19592

learning methods and approaches that involve students actively thinking (M, Rukli, & Baharullah, 2019).

The process of developing a learning tool is called the development of learning tools, and it is based on the development theory used. The objective is to create a product prototype and create methodological recommendations for its design and evaluation (Ibrahim, 2003). It is mentioned in Permendikbud No. 22 of 2016 regarding the standard of primary and secondary education that developing learning resources is a component of learning planning (Menteri Pendidikan dan Kebudayaan, 2016). Learning planning involves creating learning implementation plans, as well as learning resources, learning media, learning evaluation tools, and learning scenarios. The syllabus and lesson plans are created with the chosen learning strategy or methodology. Therefore, the teacher must choose a learning model that is able to increase the role of students in the learning process. These learning models include discovery learning.

The discovery learning model guides student activity, seeks, processes, and resolves issues by designing the learning process such that students can discover a concept while solving a problem (Cahyo, 2020). In order for students to build their own concepts of learning, the discovery learning model encourages them to explore and find out about themselves (Haryanti & Saputro, 2016). Discovery learning as a teaching methodology emphasizes the significance of assisting students in comprehending a scientific topic, the desire to actively participate in learning, and the notion that meaningful learning will result from the process of personal discovery (Bruner, 1996). Applying discovery learning models in the classroom involves a number of practical steps, including: stimulation (providing stimulation), problem statements (questions/problem identification), data collection, data processing, verification (proof), and generalization (drawing conclusions) (Widhiyantoro, Indrowati, & Probosari, 2012).

In addition, to increase the effectiveness of learning, it is expected that schools use information and communication technology such as computers and other media (Departemen Pendidikan Nasional, 2006). Therefore, to achieve creative and innovative learning, teachers must also be able to utilize technology that can be used in learning mathematics. Learning media are described as the facilities, infrastructure, facilities, supports, liaisons, and distributors that are frequently utilized in daily life to transform knowledge (Munadi, 2013). According to Gagne & Briggs (2002), learning media comprises tangible tools including books, tape recorders, cassette players, video cameras, video recorders, films, pictures, video recorders, television, and computers that are used to physically transmit the information contained in learning materials. Education has represented and continues to reflect the answers supplied by society's growth through the use of computers in classrooms and educational software in the teaching and learning process (Petrovici & Sava, 2010). There are a number of factors about the use of Dynamic Geometry Software (DGS). These factors include fostering students' ability to think critically about geometry so that their intuition can be raised to a higher degree (Straesser, 2001). Three-dimensional geometric shapes can be created with the interactive geometry software Cabri 3D. The Center National de la Recherche Scientifique (CNRS) of France and Joseph Fourier University in Grenoble began developing the Cabri technology in 1985. Software like Cabri 3D has the potential to be extremely helpful for teaching and understanding 3D geometry. The dynamic nature of the digital diagrams created with it serves as a helpful tool for assisting students in better developing idea images of geometric concepts (Accascina & Rogora, 2006). Students can explore, observe, and make geometric shapes that can be seen from various angles using the Cabri 3D programme (Khatimah, 2019).

On the other hand, a role for mathematics is that it serves as a suitable symbolic language for communication. In addition to being a tool for thinking, mathematics also serves as a means of communication between students and teachers (Maulyda, Hidayati, Erfan, Umar, & Sutisna, 2020; Zakiri, Pujiastuti, & Asih, 2018). For students to be able to solve mathematical problems with sound reasoning, illustrate the concepts with mathematical models, and then relate the process to other mathematical ideas, to contexts in everyday life, and to other disciplines, it is crucial that they

have strong mathematical communication skills (Tinungki, 2015). Mathematical communication skills are very important in learning mathematics because through communication students can organize and consolidate their mathematical thinking, and students can explore mathematical ideas (Dalimunthe, Mulyono, & Syahputra, 2022). Therefore, it is very important to build mathematical communication skills when learning mathematics.

Several studies related to the discovery learning model, namely the Hutapea research which stated that the results showed that the discovery learning learning model assisted by Cabri 3D media could improve student learning outcomes. This can be seen from the classical learning completeness also increased from 9.26% in the pre-cycle to 38.89% in the first cycle and increased again in the second cycle to 80% (Hutapea, 2019). Furthermore, Annisa's research which states the results of the assessment of LKPD development through the Cabri 3D-based guided discovery learning model from material experts with a percentage value of 84.7% with a fairly valid category, and LKPD assessment from media experts with a percentage of 89% with a very valid category and test results try the assessment in class VIII-B through a student response questionnaire with an average percentage of 86.3% in the very effective category, and the results of the distribution carried out in class VIII-A get an average percentage of 87.5% with a very effective category (Annisa, 2022). Furthermore, Nina and Mukhtar's research stated that the ability to understand mathematical concepts of students who studied with the Cabri 3D assisted problem based learning model was higher than students who studied with the Cabri 3D assisted discovery learning learning model in class VIII SMP Negeri 27 Medan (N & Mukhtar, 2017).

Based on the results of observations in one class at SMP Negeri 5 Aceh Tengah, it was found that students have not been able to communicate mathematical ideas well. Students have not been able to convey their ideas. When the teacher asks, the students are still not able to compose an argument well. Learning is still dominated or teacher-centered. Students are also not able to express a situation or problem in the form of symbols, diagrams, or mathematical models. In order to solve these issues, teachers must be able to find a strategy that would maximize students' mathematical communication abilities. It is hoped that through research on the development of learning devices using the discovery model and assisted by the Cabri 3D program, this can be an alternative to realizing a quality learning process and is also expected to improve students' mathematical communication skills. In the present study aims to develop discovery model-based learning tool using Cabri 3D interactive multimedia. The main purpose is improve student's mathematics communication ability. The learning tools produced include lesson plans, student worksheets, and test results of learning. Furthermore, another purpose of this study is to determine the validity, practicality and effectiveness of learning tools using the discovery model assisted by the Cabri 3D program, so that it is expected to help students' mathematical communication.

METHOD

This research is a development research with 4-D development model developed by Thiagarajan (Thiagarajan, Semmel, & Semmel, 1974). The 4-D development model consists of 4 main stages, namely: define, design, develop and disseminate. The definition stage aims to determine and define the requirements for learning. This stage includes front-end analysis, student analysis, material analysis and task analysis. In this stage, learning models, subject matter and tools will be obtained which will later be developed in order to achieve the expected results. Furthermore, the design stage which aims to design prototypes of teaching materials (instructional materials) for learning devices has been determined. There are 4 stages that the researchers did at this stage; format selection, media selection, preparation of tests and initial design of learning tools. Format selection, which is designing or designing product content that is developed and adapted to the learning objectives. Media selection, in the selection of media adapted to learning materials and student characteristics. The selected media is the Cabri 3D program. Then, in the preparation of

the test, the test is arranged based on the results of the formulation of learning objectives. The test referred to in this study is a mathematical communication test. At the initial design stage of the learning device, the researchers designed the lesson plan, and student worksheets.

At the develop stage, the researcher carries out activities in the form of: validation, lesson plans and student worksheets that have been designed and then given to the validator for examination of the prototype which can later be used in field trials. Furthermore, development trials are carried out when the prototype that has been assessed by the validator is then used for field trials. The results of this field trial will also be used to see whether or not there are products and learning strategies that need to be revised again. Furthermore, in the final stage; disseminate, researchers will carry out or convey the results of the product to teachers and students.

The research instruments used were validation sheets, the lesson plan validation sheet, the student worksheet validation sheet, and the mathematical communication ability test validation sheet, teacher's response questionnaire, student response questionnaires. The validators in this study were two lecturers of mathematics education. While the instruments in the form of observation sheets are observation sheets for student activities and observation sheets for the teacher's ability to manage learning. The data analysis technique used is validity analysis which aims to see how valid the teaching materials developed are.

Table 1. Validity Level Criteria

Interval *Vs*	Criteria
$4 < Vs \leq 5$	Highly Valid
$3 < Vs \leq 4$	Valid
$2 < Vs \leq 3$	Less Valid
$1 < Vs \leq 2$	Invalid

The practicality analysis aims to measure the teacher's response questionnaire. The data analysis technique of the practicality of the teacher's response questionnaire uses the percentage data analysis technique. The formula used in the analysis technique is as follows:

$$P = \frac{\sum X}{N} x100\%$$

Information:

P : Percentage score

$\sum X$: Total score

N : maximum score

Table 2. Questionnaire Percentage Analysis Criteria

Interval Percentage of questionnaire results (100%)	Criteria
81 – 100	Very Practical
61 – 80	Practical
41 – 60	Quite Practical
21 – 40	Less Practical
0 – 20	Not Practical

The effectiveness analysis aims to measure the student response questionnaire.

$$\bar{R} = \frac{\sum_{i=1}^{n} \bar{R}_i}{N}$$

Information:

$\bar{R}$ = The average score of student responses

$\bar{R}_i$ = The average score of the *i*-th student response

N = Number of students

Furthermore, to determine the achievement of the percentage of student response questionnaires, refer to Table 3 below.

Table 3. Student Response Criteria

Value Interval	Classification
$\bar{R} \geq 85\%$	Very Positive
$70\% \leq \bar{R} < 85\%$	Positive
$50\% \leq \bar{R} < 70\%$	Less Positive
$\bar{R} < 50\%$	Not Positive

Modification from Prasetyo (2012)

Analysis of mathematical communication ability test data aims to measure whether or not there is an increase in students' mathematical communication skills. The acquisition for mathematical communication test scores is processed using the N-Gain formula.

RESULT AND DISCUSSIONS

Result

Define Stages

The definition stage aims to determine and define the requirements for learning. This stage includes front-end analysis, student analysis, material analysis and task analysis. In the front-end analysis, the process begins with observation. From the observation, it was found that mathematics learning that took place in class IX during tended to be dominated by teachers with conventional learning. Furthermore, students have difficulty understanding geometry material in mathematics learning. In the student analysis, it was obtained based on the background knowledge of students, the curved side space material was difficult for students to understand and difficult for students when given story questions. Furthermore, students have never participated in learning using the discovery learning model using media assistance and have never used the Cabri 3D application. Finding the key ideas that will be taught and organizing them in a systematic manner is the goal of the material analysis stage. To establish the kind of teaching materials to be generated, material analysis can be done by examining core competencies that make reference to basic competencies and basic competency indicators. The researcher chose the cylinder, cone and sphere material because students found it difficult to understand the material. Task analysis is conducted after understanding the subject to teach so that it can be seen the tasks that students must perform throughout the learning process. Additionally, when creating learning objectives, it is important to take into account the core competencies and fundamental skills required by the 2013 curriculum.

Design Stages

There are 4 stages that the researchers did at this stage; format selection, media selection, preparation of tests and initial design of learning tools. In selecting the format, the researcher designed the product content that was developed and adapted to the learning objectives. In this case, the lesson plan format used is adjusted to the principles and steps in learning using the discovery learning model. The learning content refers to the results of the material analysis, the results of the task analysis, and the specification of the learning objectives that have been formulated at the definition stage. Through the application of discovery learning models, students are expected to be more active and learning becomes more meaningful for students. In the selection of media, it was determined that the learning media needed in the implementation of the Discovery Learning model learning on the Cylinder, Cone and Sphere sub-materials was using the Cabri 3D application media. Furthermore, the preparation of tests that are based on the results of the formulation of learning objectives. The test in question in this research is a mathematical communication test. At the initial design stage of the learning device, the researchers designed the lesson plan, and student worksheets.

Develop Stages

Validating the research instrument is a crucial phase of the development process. At the develop stage, the researcher carries out activities in the form of: validation, lesson plans and student worksheets that have been designed and then given to the validator for examination of the prototype which can later be used in field trials. The research instruments used were validation sheets, the lesson plan validation sheet, the student worksheet validation sheet, and the mathematical communication ability test validation sheet, teacher's response questionnaire, student response questionnaires. The results of the lesson plan validation which were validated by 2 experts showed valid results. This is shown in table 4.

Table 4. The Results of Expert Assessments on The Validity Aspects of The Lesson Plan

No	Aspects	I_i	Criteria
1	Format	3.8	Valid
2	Contents	4.5	Valid
3	Language	3.75	Valid
	Vs	4.01	Valid

The next validation is the student worksheet. Aspects that were validated were format, content and language.

Table 5. Discovery Learning Syntax for Stimulation, Problem Statement, and Data Collection

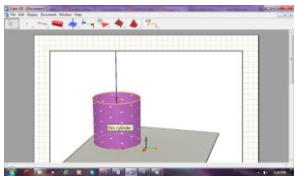
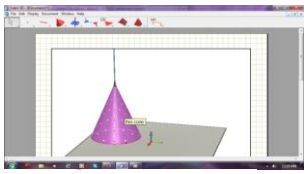
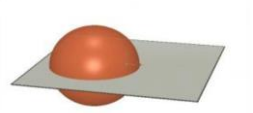
No	Stages	Teacher activities	Student activities
1	Stimulation	Provide problems that lead to learning, such as the introduction of cylinder, cones and spheres and Cabri 3D software. The teacher explains how to make cylinder, cones and spheres using the Cabri 3D application.   	Understand the problems given by the teacher and listen to the material given by the teacher
2	Problem Statement	The teacher provides opportunities for students to identify questions related to the images presented and will be answered through learning activities by asking questions about the material of cylinder, cone and sphere.	Identifying problems on student worksheets in groups
3	Data Collection	Provide opportunities for students to collect relevant information that they find from student worksheets	Observe and collect relevant information from student worksheets.

Table 6. Discovery Learning Syntax for Data Processing, Verification, and Generalization

No	Stages	Teacher activities	Student activities
4	Data Processing	Guiding and observing students in carrying out the learning process using Cabri 3D software	Manage the data that has been collected by following the steps contained in the student worksheet
5	Verification	Provide opportunities for students to find new understanding by explaining the answers to the questions given in turn, then the teacher provides reinforcement about the results of the discussion	Re-explaining verbally the understanding of the task that has been done
6	Generalization	Help students conclude the results of activities	Students conclude the results of the activity

Table 7. The Results of Expert Assessments on The Validity Aspects of The Student Worksheet

No	Aspects	I_i	Criteria
1	Format	3.9	Valid
2	Contents	4	Valid
3	Language	4.25	Valid
	Vs	4.05	Valid

The results from table 7 show that the average assessment on the three aspects is 4 with valid criteria. Furthermore, the validator also provides suggestions for improving student worksheets.

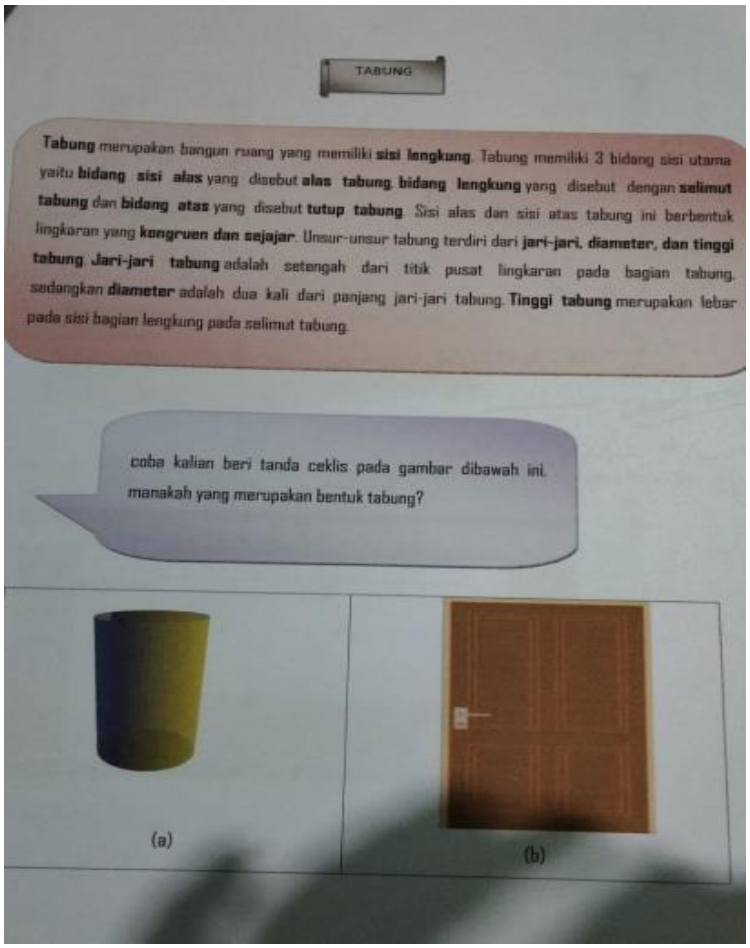


Figure 1. Student Worksheets Before Revision

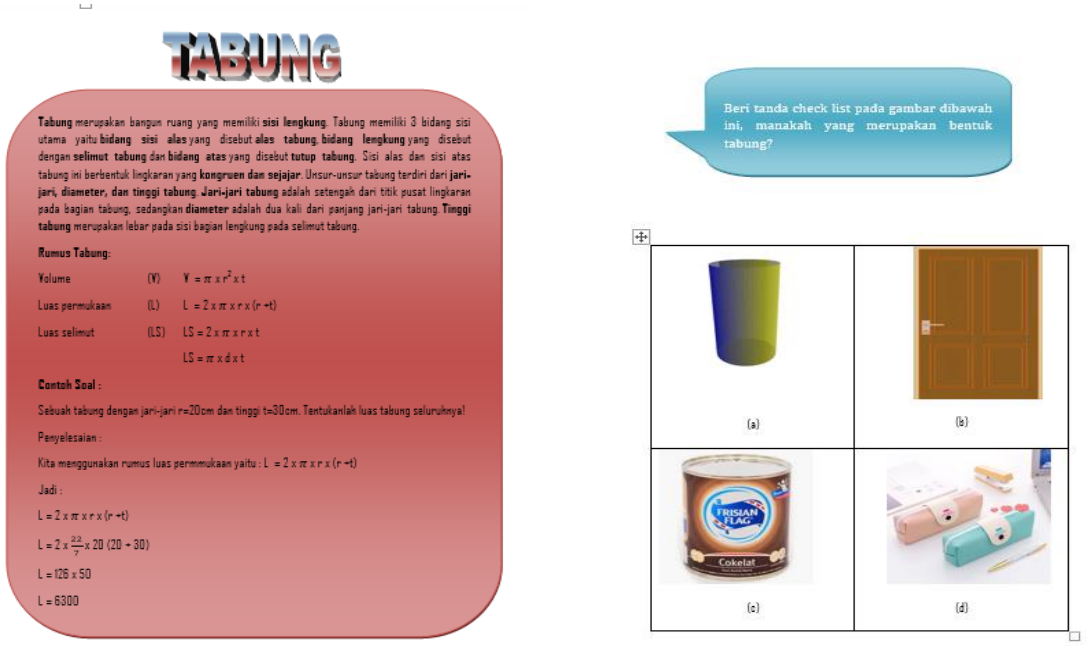


Figure 2. Student Worksheets After Revision

Furthermore, the results of the validation of the mathematical communication test are shown in table 8.

Table 8. The Results of Expert Assessments on The Validity Aspects of The Mathematical Communication Ability Test

No	Aspects	I_i	Criteria
1	Format	3.75	Valid
2	Contents	3.42	Valid
3	Language	3.8	Valid
4	Vs	3.65	Valid

The results from Table 8 on the validation of the mathematical communication test show the average assessment on the three aspects is 3.65 with valid criteria.

The teacher's response questionnaire aims to obtain information about the practicality of learning tools based on the teacher's predictions and considerations. This questionnaire is given to the teacher at the end of the meeting, precisely when the learning outcomes test is carried out. From the results of the teacher's response questionnaire analysis, it was found that every statement that describes the practicality of 75% - 100% is included in the practical and very practical category. While the average practicality score obtained is 85% included in the very practical category.

Development trials are carried out when the prototype that has been assessed by the validator is then used for field trials. The product trial was conducted at SMP Negeri 5 Central Aceh, class IX, which consisted of 13 students. To see the effectiveness of the developed student worksheet, after it was implemented in the learning process students were given a questionnaire to find out their response in using student worksheets. Based on the results of the student response questionnaire data analysis, it was concluded that students had a positive response, namely 92.12% of the components and learning activities. The positive response of students is inseparable from the learning situation by using the discovery learning model assisted by the 3D Cabri application and the developed student worksheets.

Data on the effectiveness of learning outcomes were obtained from students' cognitive pretest and posttest scores in learning. Based on the pretest-posttest data that has been carried out,

the data obtained are then analyzed with n-gain to determine the increase in student learning outcomes.

Table 9. N-Gain Data

Score	Pre-Test Data	Post-Test Data
Total Students	13	13
Lowest Score	24	36
Highest Score	80	92
Maximum Score	100	100
Average	44	83.69
N-Gain	0.70	
Criteria	Medium	

Disseminate Stages

In the final stage, namely dissemination, the researcher conducts or conveys the results of the product to teachers and students. The distribution was carried out at schools at the SMP/MTsN level, namely at MTsN 3 Central Aceh and SMP 14 Central Aceh.

Discussions

The results of the lesson plan validation are presented in table 4, it can be seen that the results of the average assessment of all aspects of the lesson plan validation validated by the two validators indicate that the discovery learning implementation plan is declared valid, because the overall average value is 4.01. Then the results of the validation of the student worksheets in table 6 which were validated by two validators showed an average value of 4.05 which means it is valid. Furthermore, the results of the validation of the mathematical communication test in table 8 show an average value of 3.65 which also means it is valid. This is in line with the research conducted by Rahma and Tatag who also examined the development of learning tools using the discovery learning model which showed valid validation of lesson plans, student worksheets and learning outcomes tests. This is in accordance with the language of clarity of instructions as well as the truth of the content/material and conformity with the mathematics curriculum (Khoirunnisa & Siswono, 2013).

A good learning tool should be practical in addition to achieving the validity criteria. The ease with which teachers and students can use a product is a factor in its practicality (Hendri & Kenedi, 2018). Practicality can be seen in the aspect of ease of use, including: easy to set up, stored and can be used at any time, the time required for implementation should be very short, fast and precise, product appeal to students, easy to interpret by educators and have the same equivalence so that it can be used as a substitute or variation (Sukardi, 2019). Furthermore, the analysis of practicality through the results of the teacher's response questionnaire showed the results of 85% with very practical criteria. From the assessment given by the teacher, it can be seen that the lesson plans and student worksheets make it easier for the teacher to present learning materials and the use of student worksheets helps the success of learning. Additionally, it indicates that the created discovery learning tools are regarded as excellent and usable by others. It may be inferred that the lesson plan prepared is useful because the teacher's capacity for managing student learning is in the very good range and the overall assessment of the lesson plan indicates that the lesson plan can be employed (Khoirunnisa & Siswono, 2013).

The effectiveness of the learning devices that need to be created must be tested, as evidenced by the results of the students' learning after using the created learning resources (Hendri & Kenedi, 2018). The analysis of the effectiveness of student worksheets shows the results of 92.12% with very positive criteria and the average value of the results of increasing mathematical communication skills is 0.70. It is stated that mathematical communication skills increased in the medium category. This is also in line with Khoirunnisa and Siswono's research which states that student activities in discovery learning are said to be effective. Based on the response

questionnaire given to students, it showed that more than 75% of students gave a positive response (Khoirunnisa & Siswono, 2013).

So, we can conclude that discovery learning-based mathematics learning tools with the help of the Cabri 3D application developed can be used in the learning process and can help students solve mathematical problems on geometry material. The validation and testing of learning tools show that the learning tools meet the criteria for the learning tools developed, referring to being valid, practical, and effective. From the test results, it is also clear that students in the medium category are getting better at communicating mathematical ideas. This is consistent with Khoirunnisa and Siswono's research, which revealed that the communication abilities of 68% of students in class VIII-A at SMP Negeri 13 Surabaya who participated in discovery learning on blocks and cubes were good (Khoirunnisa & Siswono, 2013). Furthermore, other research states that the ability of students' mathematical communication with the discovery learning learning model on the 2013 curriculum implementation learning device is better than students' mathematical communication skills with conventional learning (Dina, Mawarsari, & Suprapto, 2015). Other research states that the results of the study show that the discovery learning model assisted by Cabri 3D media can improve student learning outcomes (Hutapea, 2019). Students who use the Cabri application-assisted discovery learning paradigm have greater mathematical aptitude than students who do not use the application (Sariani, 2020). Therefore, research on the development of learning tools using other models can help the success of the students' learning process in understanding mathematics.

CONCLUSION

This study resulted in a junior high school mathematics learning tools on the cylinder, cone and sphere material by using a discovery learning model assisted by the Cabri 3D application. The development of learning tools with discovery learning models assisted by the Cabri 3D application adapting the 4D model development procedure consisting of four stages, namely the define stage, the design stage, the development stage and the dissemination stage. The learning tools produced include lesson plans, student worksheets, and test results of learning. The validation and testing of learning tools show that the learning tools meet the criteria for the learning tools developed, referring to being valid, practical, and effective. From the test results, it is also clear that students in the medium category are getting better at communicating mathematical ideas.

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