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DEVELOPMENTS OF INSTRUCTIONAL MODELS BASED ON MATHEMATICS COMMUNICATION SKILLS IN INTEGRAL CONCEPTS AND APPLICATIONS

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Abstract

The problem of this research is the low mathematical communication skills of students in integral calculus courses. The purpose of this study was to develop a learning model based on Mathematical Communication skills on integral concepts and applications, and to determine the feasibility and effectiveness of learning models based on Mathematical Communication skills on integral concepts and applications. This research method is a research and development method. The research subjects were 43 students of the Mathematics Education Department at Halu Oleo University. Data collection techniques using questionnaires, interviews and test techniques. Data analysis was carried out in a quantitative and qualitative descriptive manner. The results of the data analysis showed that the integral concept and application learning materials based on the assessment of mathematics learning experts and learning design experts reached 86.3% and 89.16% in the very good category. While the results of the student assessment showed 87.5%. The small group evaluation results showed an average percentage of 88.2% with a very good category. The results of the large group trial reached a percentage value of 90.1% in the very good category. Therefore, the development of a learning model is able to improve students' mathematical communication skills on integral concepts and applications.

Keywords: Developments Instructional Models, Mathematics Communication Skills

Abstrak

Masalah penelitiaan ini adalah rendahnya kemampuan komunikasi matematis mahasiswa pada matakuliah kalkulus integral. Tujuan penelitian ini adalah untuk mengembangkan model pembelajaran berdasarkan kemampuan Komunikasi Matematik pada konsep dan aplikasi integral, dan untuk mengetahui kelayakan dan kefektifan model pembelajaran berdasarkan kemampuan Komunikasi Matematika pada konsep dan aplikasi integral. Metode penelitian ini adalah metode research and development. Subjek penelitian adalah mahasiswa Jurusan Pendidikan Matematika Universitas Halu Oleo sebanyak 43 mahasiswa. Teknik pengumpulan data menggunakan angket, wawancara dan teknik tes. Analisis data dilakukan secara deskriptif kuantitatif dan kualititatif. Hasil analisis data menunjukkan bahwa bahan pembelajaran konsep dan aplikasi integral berdasarkan penilaian ahli pembelajaran matematika dan ahli desain pembelajaran mencapai 86,3% dan 89,16% dengan kategori sangat baik. Sedangkan hasil penilaian mahasiswa menunjukkan 87,5%. Hasil evaluasi kelompok kecil menunjukkan rata-rata persentase 88,2% dengan kategri sangat baik. Hasil Uji coba kelompok besar mencapai nilai persentase sebesar 90,1% dengan kategori sangat baik. Oleh karena itu, pengembangan model pembelajaran mampu meningkatkan kemampuan komunikasi matematik mahasiswa pada materi konsep dan aplikasi integral.

Kata Kunci: *Kemampuan Komunikasi Matematik, Pengembangan Model Pembelajaran.*

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INTRODUCTION

The development of science and technology that is so advanced today requires graduates of every university to be to be competent. These competencies can be in the form of integration of knowledge abilities, skills, and attitudes shown in solving every problem encountered and by the field occupied. One aspect of knowledge that needs to be possessed is the ability to communicate ideas, mathematical ideas in written or oral form, the ability to read a situation in the form of pictures or writing, and the ability to create mathematical models that can be used in problem-solving.. This ability is known as mathematical communication skills.

Communication skills have an important role in learning mathematics, especially in constructing students' knowledge and understanding through instruction. Communication is a way of solving and clarifying problems with understanding (Setiyani et al., 2020). Mathematical communication skills are the ability to express mathematical ideas with symbols, tables, diagrams, or other media to clarify mathematical problems (Yusra & Saragih, 2016). So, mathematical communication ability is the student's ability to interpret and solve mathematical problems in the form of symbols, tables, pictures, diagrams, and graphs and express ideas in writing in the form of mathematical models. Olteanu & Olteanu, (2013) state that effective communi-cation is a process where teachers provide and convey meaning in an effort to create a shared understanding and there is meaningful interaction between teachers and students.

Furthermore, the results of the study indicated that only 1 in 3 students were able to express mathematical ideas; understand, interpret and assess or respond to mathematical ideas; use terms, notations, and symbols to represent mathematical ideas (Rohid et al., 2019). Therefore, the teacher must stimulate students' mathematical communication skills through creative and innovative learning.

These various studies show that mathematical communication skills can be improved through development research and experimental research both in elementary and junior high schools. However, no one has developed a learning model based on mathematical communication skills on integral concepts and applications. Therefore, it is necessary to develop a learning model based on mathematical communication skills for students of mathematical study programs, especially on integral concepts and applications in the hope of producing a learning model, learning materials, as well as mathematical communication skills for students at the elementary level of the mathematics study program to increase as well as learning activities, become efficient and effective.

The development of learning models to improve students' mathematical communication skills can be done using several methods: (1) designing class assignments, (2) class activities in the form of pairs, small groups, feedback, examples from students, discuss and share, read and write. (3) encourage communication; (4) self-study support; (5) the use of formative and summative assessments. The result found that the involvement of students to speak, listen, read, write and reflect in mathematics learning and problem-solving will increase their awareness of mathematical thinking and communication skills (Rahman et al., 2012).

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Then the development of digital learning modules, the use of contextual-based learning, and reciprocal learning can improve students' mathematical communication skills (Setiyani et al., 2020); Yusra & Saragih, 2016); (Qohar & Sumarmo, 2013). Then there is a relationship between visual media and students' mathematical communication skills (Ryve et al., 2013). In learning mathematics students' mathematical communication abilities must be explored more deeply because these abilities are important for students to master (Fonger, 2019).

The development of Instructional models is a systematic process of identifying learning problems, developing strategies and learning materials, and evaluating their effectiveness and efficiency in achieving instructional goals. This study tries to develop an instructional model based on mathematical communication skills on integral concepts and applications through the Dick and Carey model. Formative evaluation is needed to determine the feasibility and quality of the model development result (Roubides, 2015). Furthermore, by combining the Dick and Carey, Wulf and Schave, Posner and Rudnitsky models by integrating computers in the mathematics curriculum can help students understand and retain basic mathematical concepts (Eti, 2009). Then the use of the Dick and Carey model at the Define and Dissemination stages in developing mobile applications for two-dimensional learning can facilitate students to learn independently (Jumaat & Tasir, 2013).

RESEARCH METHOD

This research is development research with 43 students as the research subject and the location of this research is in the Department of Education Mathematics, Halu Oleo University. The stages of this research use the stages contained in the Dick and Carey development model which consists of the first stage, the identification stage, which consists of three steps, namely 1) identifying general learning objectives, 2) carrying out instructional analysis, 3) analyzing the context and characteristics of students. The second stage, the development stage, consists of four steps, namely 1) writing specific learning objectives, 2) developing evaluation instruments, 3) developing and selecting learning strategies, and 4) developing and selecting learning materials. The third stage is the evaluation and revision stage which consists of designing and carrying out formative evaluations (Suparman, 2014).

The research instruments used were interviews, questionnaires, and tests of mathematical communication skills. Interviews were used to identify general learning objectives. Questionnaires were used during the formative evaluation aimed at mathematics learning experts, learning design experts, and students. Questionnaires were given to mathematics learning experts with indicators of the suitability of the material with the objectives, the accuracy of the material, the language used, the strategy for organizing the material, assessment. The questionnaire given to mathematics learning design experts has the dimensions of formulating instructional objectives, material organizing strategies, and student assessments. While the questionnaire was given to students as an indicator of the quality of the display of learning materials, the quality of learning materials, and the use of learning materials.

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The questionnaire used during the trial had indicators of the quality of learning materials, the quality of the learning process, and the quality of mathematical communication tests. Then the mathematical communication test in the integral calculus course contains five numbers with indicators (1) using the concept of sigma notation for solving daily life problems, (2) determining the length of each partition interval [a, b], compiling an area model A(Rn) with inner or outer polygons and can determine the area of the area, (3) draw collated functions on the coordinate system, create an integral model using the addition of intervals and calculate the area in question, (4) determine the area of the flat plane above and below the axis -x and (5) determine the volume of the rotating object using the ring method.

The data collection technique was carried out by conducting interviews with integral calculus lecturers to find out the objectives of integral calculus learning, students who had programmed integral calculus courses. Then the questionnaire was given to learning and learning design experts, 43 students. Meanwhile, the test of students' mathematical communication skills in the integral calculus course was given in trials in small groups and large groups. Data analysis was carried out descriptively qualitatively and descriptively quantitatively

RESULTS AND DISCUSSION

Instructional Model Development using the Dick and Carey model is divided into three stages, namely the identification, development and evaluation stages. The explanation of every stages can be seen in the next explanation.

Identification Stage

Identification consists of the identification of instructional needs, instructional analysis, and analysis of student's initial behavior and characteristics. The Identification of instructional needs through gap analysis needs to be done before developing a learning model. The instrument used in this identification is an interview guide. Based on the results of interviews that the results of the identification of instructional needs indicate that there is a gap between the competencies obtained by students and the competencies expected. So that the solution step is to carry out instructional activities by developing a learning model. Furthermore, in the identification, the target group is determined who will take part in the instructional activities in the integral calculus course. Students who are involved in learning are students majoring in mathematics education who have programmed differential calculus courses. Then based on the results of interviews from various sources, information was obtained that the purpose of studying integral calculus was "to understand the concept of integral and be able to apply it in solving everyday problems". Based on information from several research subjects, the general objective of integral calculus learning is "after attending integral calculus learning students are expected to be able to master the concept of integral calculus and be able to apply it in the field of mathematics and everyday life".

The instructional analysis is carried out to identify the skills and knowledge that students must have in learning so that the general objectives of learning can be achieved. Learning analysis is a series of procedures for

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identifying supporting skills or knowledge that are relevant to general learning objectives. Instructional analysis shows the most basic competence map to the highest competency. In compiling sub-competencies, it is carried out hierarchically and procedurally. The results of the instructional analysis can be seen in Figure 1.

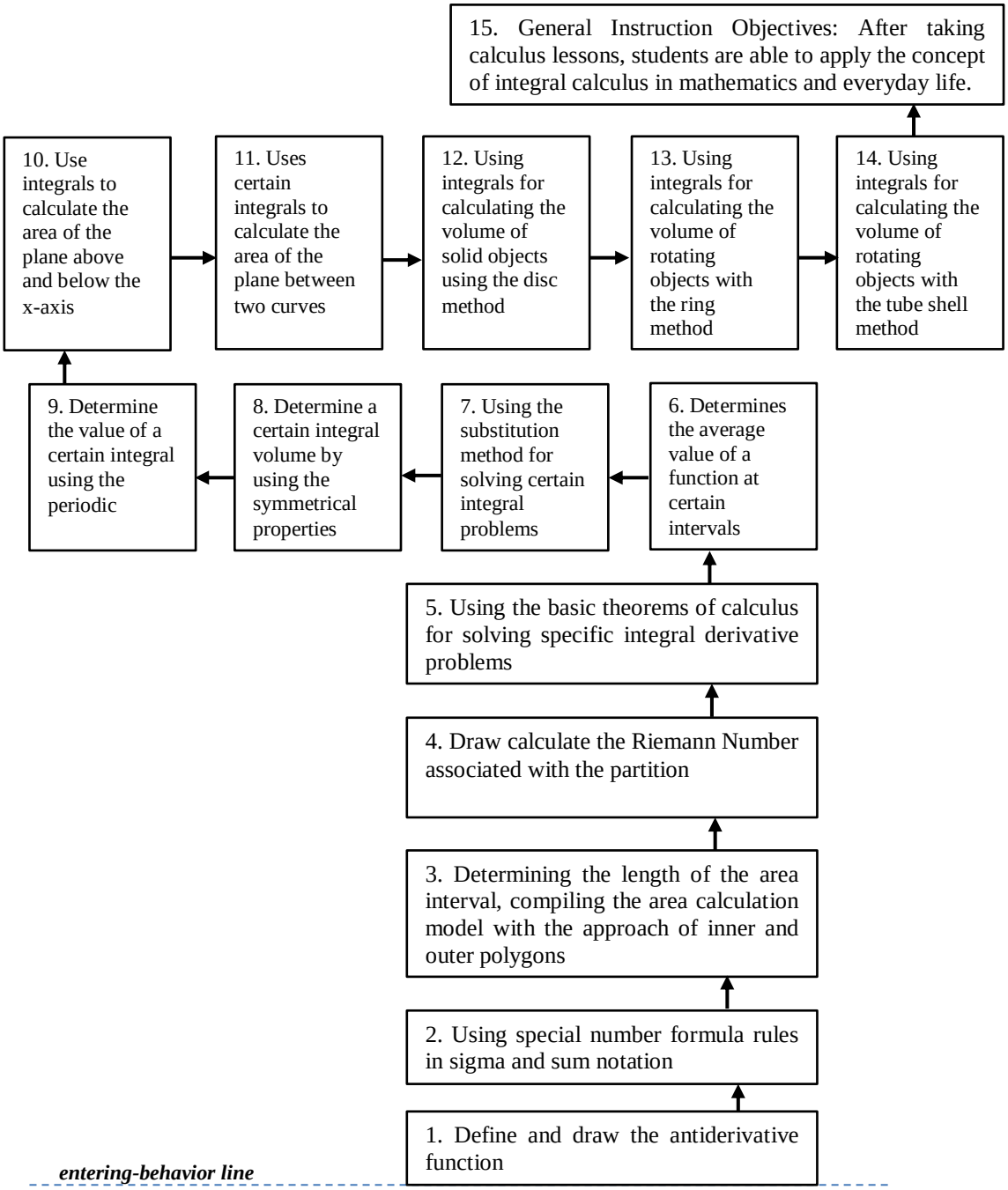

Figure 1 The Results of the Instrutional Analysis

Analysis of the initial behavior of students is to determine the competencies that have been mastered and those that have not been mastered. These competencies are categorized as very good, good, moderate, bad, and

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very bad. The competencies mastered are in the very good and good categories, while the competencies that have not been mastered are in the sufficient, bad, and very bad categories. The initial behavior of students before taking integral calculus lessons was obtained from the students concerned and lecturers who were influential in integral calculus courses. The technique used to obtain data on students' initial behavior is a questionnaire. Based on the results of data analysis, students' basic competencies in learning concepts and integral applications are on average in the low category. Furthermore, the results of the assessment of the course lecturers on students' abilities in integral concepts and applications are also still low. This shows that the data obtained from students and lecturers show the same results.

Then based on the results of interviews, the following characteristics of students were obtained, namely, students who will attend lectures with integral concepts and application materials motivated to understand the material, namely to compete and get good learning outcomes. Students have the habit of studying, reading, and doing assignments independently and through a discussion process with their peers. Students have a disciplined attitude and are confident in their abilities. Students have learning resources and the ability to search for relevant literature through the internet/online network.

Development Stage

The development stage, consists of four steps, namely 1) writing specific learning objectives, 2) developing evaluation instruments, 3) developing and selecting learning strategies, and 4) developing and selecting learning materials. Based on the instructional analysis, specific learning objectives or special competencies in integral concepts and applications are obtained. Specific learning objectives are abilities that are expected to be achieved by students after participating in learning. The next step is the preparation of an assessment tool used to measure the level of student mastery of the competencies listed in the instructional objectives. The steps in developing an assessment tool are (1) determining the purpose of the assessment, and (2) making a blueprint test. In this development, the measurement is done through a written test, considering that the specific learning objectives to be achieved mostly include the cognitive domain. The number of questions that were compiled was five questions in the form of a mathematical communication test that represented the instructional objectives that were prepared.

The development of a learning strategy by describing the components included in the concept of a learning strategy which includes (1) instructional objectives that contain competencies that are expected to be achieved by students at the end of learning; (2) a sequence of instructional activities; (3) instructional content or material in an order that corresponds to the order of instructional objectives; (4) methods, media, and tools usually reflected in the launch system; (5) the learning time needed.

In the Instructional strategy that develops specific learning objectives according to the previous steps, the sequence of learning activities consists of preliminary activities, core activities, and closing activities. The method used is the deductive, discovery, contextual inductive method. The media used was PowerPoint media and the tools used were computer and in focus. The

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learning time used by students is 150 minutes face-to-face. The strategy used is to improve students' mathematical understanding and communication of integral concepts and applications.

In the step of developing learning materials, refer to specific learning objectives, and learning strategies. The teaching materials developed are in the form of (a) a lecturer's manual as a guide for the use of teaching materials, and (b) student teaching materials, as a source in the student learning and learning process. The results of the development of learning materials are evaluated by field experts and learning design experts.

Evaluation and Revision

Evaluation of the development of a context-based learning model based on mathematics communication skills is pursued through formative evaluation. Formative evaluation is carried out to assess the quality of the learning model development and to determine the feasibility of the integral calculus learning model. The formative evaluation consists of one-to-one expert evaluation, one-to-one student evaluation, small group evaluation, and large group evaluation. The results of the one-to-one expert evaluation can be seen in Table 1.

Table 1. Learning material validation results through one-to-one experts

Validator	Indicator	Percentage (%)	Category
Mathematics Instructional Expert	suitability of the material for the purpose,	85,00	Very Good
	accuracy of the material	86,67	Very Good
	the language used	86,00	Very Good
	material organizing strategy	88,00	Very Good
	aspects of the assessment	86,00	Very Good
Average		**86,33**	**Very Good**
Instructional Design	the suitability of the goals achieved	88,30	Very Good
	material organizing strategy	91,67	Very Good
	student assessment	87,50	Very Good
Average		**89,16**	**Very Good**

Based on table 1 shows that the average percentage of validation results by mathematics learning experts on calculus learning materials reaches 86,33%. Meanwhile, the average percentage of validation results by learning design experts on calculus learning materials reached 89,16%. This means that context-based integral calculus learning materials are feasible to use even though there are several notes for improvement.

Then after improving the learning materials based on input from design experts and mathematics learning experts, then a one-to-one evaluation of students is carried out. In this step, the developer provides learning materials to three students to study in order to provide assessments and suggestions for the learning materials. The results of student assessments of context-based integral calculus learning materials can be seen in Table 2.

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Table 2. Results of Learning Material Validation through one-to-one students

Indicator	The performance score for each indicator			Percentage of achieve-ment for each indicator			Average
	Validator			Validator			
	1	2	3	1	2	3	
Quality of display Learning materials	35	37	36	87,5%	92,5%	90,0%	90,00%
Quality of Instructional material	28	26	27	93,3%	86,7%	90,0%	90,00%
Use of Instructional materials	9	9	8	90,0%	90,0%	80,0%	86,67%

The average percentage of achievement for indicators of the quality of the display of learning materials reaches 90% in the very good category. The average percentage of achievement for indicators of the quality of learning materials reaches 90% in the very good category. Then the average percentage for the indicator of the use of learning materials reaches 86,67% in the good category. After revising the learning materials based on input from three students, then a small group evaluation was carried out involving ten students, representing high, medium, and low abilities. The results of the material evaluation and implementation of learning through small group trials showed in Table 3.

Overall, based on table 3, the learning model through small group trials reached 89.9% which was in the very good category. The results of the assessment of students' mathematical communication skills during small group trials obtained a minimum score of 62,0, a maximum value of 84,0, an average value of 75,2 with a good category, and a standard deviation of 9,3.

Tabel 3. Results of insructional material validation through small group

No	Indicator	Score	Percentage
1	Quality of Learning materials	21,7	86,8%
2	Quality of Instruction	9,1	91%
3	Mathematical communication test quality	9,2	92%
	Average	**13,33**	**89,9%**

The Effectiveness of The Learning Model Based on Mathematical Communication Skills

Furthermore, the revised learning materials were then tried out again to 30 students which was called field trials. Field trials are carried out in the form of integral calculus learning by using calculus learning materials as a learning resource. The result of effectiveness tet can be seen in Table 4.

Table 4. Results of insructional material validation large group trials

No	Indicator	Large Group Trials	
		Score	Percentage
1	Quality Instructional materials	22,9	91,6%
2	Quality of Instructional	9,3	93,0%
3	Quality mathematics communication test	9,4	94,0%
	Average	**13,87**	**92,87%**

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The average percentage of the results of the validation of the learning model for the Quality of Learning Materials indicator reached 91.6%, with the very good category. The quality of learning indicator reaches 93% with the very good category and for the quality indicator, the mathematics communication test reaches 94%. Overall, the learning model through a large group trial test reached 92.87% with the very good category. This shows that the materials and quality of learning based on mathematics communication skills are appropriate for use by students majoring in mathematics education. Furthermore, the results of the descriptive mathematics communication skills test obtained a minimum value of 66.0, a maximum value of 91.0, an average value of 76.1 with a good category, and a standard deviation of 7.6. The average value of students' mathematical communication skills is greater than the minimum completeness criteria in integral calculus learning, namely 65. In quantity, more than 75% of students have achieved mathematical communication skills of> 65. This shows that the development of integral calculus learning models is effective in improving students' mathematics communication skills.

The results showed that the development of a learning model could improve students' mathematical communication skills in integral calculus courses. The results of this study are in line with the results of research that there is a positive change in students' mathematical communication skills after being given context-based learning (Yusra & Saragih, 2016). Then the results of research that the development of realistic mathematics learning tools can improve students' mathematical communication abilities (Nurhayati, 2017). Then the development of hypermedia-based e-books and the use of Problem Based Learning can improve student learning outcomes in integral calculus courses (Awaludin et al., 2020; Awaludin et al., 2020). Students' mathematical communication skills can be improved by training students to solve real-world problems in learning(Tong et al., 2021). Development of Rainbow Math Cards in the TGT Learning Model can Improving Mathematical Communication Skills (Sugianto et al., 2022).

The advantages of the developed learning model are (1) using context-based learning materials, and based on mathematical communication skills, (2) using learning strategies that are prepared based on competency analysis, learning objectives, and assessment instruments, (3) learning materials are developed based on learning objectives, (4) the accuracy of the material and language used, (5) the organization of structured material, (6) the assessment is developed based on specific learning objectives.

The disadvantages of the developed learning model are (1) this learning model has not yet integrated artificial intelligence-based learning media, (2) to implement the developed learning model, various learning methods must be applied, (3) the development process is relatively long, and (4) it requires costs. major role in developing the model.

This development research produced a valid and practical learning model in the form of learning strategies and context-based learning materials to improve students' mathematical communication skills. An increase in mathematical communication skills occurs after applying a context-based

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learning model with the help of learning materials that have been tested for feasibility in several aspects. The first aspect is the suitability of learning materials with learning objectives so as to enable students to study lecture material efficiently and effectively. The second aspect, the use of discussion in the material is in accordance with cognitive development so that it makes it easier for students to understand the material. The third aspect is organizing structured material so that students learn lecture material more easily. Compatibility of goals with assessment instruments. Then the quality of learning that provides opportunities for students to be actively involved in constructing knowledge so that the concepts obtained are more meaningful and easy to use in solving problems. This is in line with the theory of constructivism.

CONCLUSION AND SUGSESTION

The learning model based on mathematical communication skills on integral concept material and applications has been developed in a valid and practical manner. This research is still limited to integral concept and application material, therefore, future researchers can develop learning models on other materials and designed with more attractive designs with the help of digital media so as to increase students' motivation and mathematical skills and become a reference for students in learning online. independent. The results of this study are expected to become a treasure trove of knowledge in learning mathematics and become a reference for subsequent research.

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