

Development of Mathematics Learning Tools With Problem-Based Learning Models to Increase Connection Ability in Junior High School

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Abstract. (1) to analyze how the validity, practicality, and effectiveness of learning tools developed through problem-based learning algebra models in class VII junior high school 4 Tarutng; (2) to analyze how to increase mathematical connection skills using a device developed through an algebraic material model in class VII junior high school 4 Tarutung; This research is classified as Development Research using the learning development model of Thiagarajan and Semmel. This research aims to: (1) analyze how to increase mathematical connection skills using a device developed through an algebraic material model (Four D Model). The findings of the study indicate that: (1) The learning tools of the Problem Based Learning Model are valid, practical, and effective; (2) Increasing students' mathematical connection abilities by using problem based learning learning models on algebraic material; and (3) Increasing students' interest in mathematics through the use of problem based learning learning models on mathematical material.

Keywords: Development of learning tools, Problem Based Learning, mathematical connection ability,

1 Introduction

Mathematics is one of the subjects that students are exposed to throughout their educational careers, beginning with early childhood education and continuing all the way to university level education. This coverage of the subject spans the entire educational spectrum. Mathematical understanding, in both its applied and its reasoning facets, is an essential component of the efforts that are put out in order to acquire a firm grasp of scientific and technological concepts. Mathematics can be regarded of as either a set of tools or a mindset that assists in connecting information with an issue in order to solve the problem at hand. Because of this, the teaching of mathematics in schools need to act as a vehicle for the growth of students' intelligence, capacities, and skills, as well as for the formation of their personalities. The process of learning mathematics involves thinking because it involves a process of thinking, and because the process of thinking involves humans making associations between pieces of knowledge that The

process of learning mathematics requires students to think, because it is via thinking that the meanings of mathematical concepts are first stored in their heads.

The study of mathematics should fulfill two basic aims: (1) formal goals, which emphasize children's thinking and personal formation, and (2) material goals, which emphasize the application of mathematics and mathematical skills, notably the ability to solve mathematical problems. Math should achieve both purposes. This must be done. This is in line with the National Council of Teachers of Mathematics' educational goals (NCTM, 2000). These goals are: (1) developing the ability to communicate mathematically (also called "mathematical communication"); (2) developing the ability to reason mathematically (also called "mathematical reasoning"); (3) developing the ability to solve mathematical problems (also called "mathematical problem solving"); (4) developing the ability to link ideas mathematically (also called "mathematical connections"); and (5) d. (positive attitudes toward mathematics).

In point of fact, the standard of mathematics education is still quite poor, and it is necessary to improve it in order to make progress; this is an issue that requires attention. In other areas, a sizeable percentage of educators still cling to an antiquated teaching approach known as the transfer of knowledge in the context of modern mathematics education.

This is shown by Indonesian kids' weak math performance compared to other students. Indonesia scored 500 on TIMSS (Trends in International Mathematics Science Study) and PISA (Program for the International Assessment of Students), with a standard deviation of 100. Trends in International Mathematics and Science Study and PISA are acronyms. TIMSS stands for Trends in International Mathematics and Science. Program for International Student Assessment (PISA):

Table 1. PISA and TIMSS . result data

Year	PISA	TIMSS
1999	-	34 from 38 country
2000	39 from 41 country	-
2003	38 from 40 country	35 from 46 country
2006	50 from 57 country	-
2007	-	36 from 49 country
2009	61 from 65 country	-
2011	-	38 from 42 country
2012	41 from 65 country	-
2015	69 from 76 country	36 from 49 country

Source: Research and Development Agency of the Ministry of Education and Culture, 2016

The existing poor level of education, as was addressed before, needs to be upgraded so that students can better understand fundamental subjects like mathematics, which are relevant to their everyday lives. A nation that wishes to be able to grasp science and technology properly also has to develop workers who have suitable knowledge of mathematics. This is because such a nation needs to be able to master both science and technology. This is due to the fact that it is necessary for a nation to have a solid grasp on both science and technology. One of the students' mathematical powers is the capacity to make mathematical connections, which is one of the mathematical capabilities that should be carefully promoted among children. The value of this ability cannot be overstated. This is due to the interrelated nature of the mathematical concepts and ideas that are involved in this scenario. Mathematical connections are inspired by the fact that mathematics is not partitioned into a variety of fields; rather, mathematics is a cohesive

subject that is hierarchical in its delivery and understanding. This feature helps explain why mathematical connections are so important. In addition, mathematics is not a separate field from other branches of science, nor does it live in a vacuum in day-to-day life. Both of these statements are true.

Because mathematical connections have the power to make links between other mathematical concepts, it will be much simpler for students to comprehend the relationship that exists between various mathematical concepts. Students will have a more comprehensive and in-depth understanding of mathematics if they have such knowledge. In addition, memorization will result in fewer and fewer mistakes, making the process of acquiring mathematical knowledge simpler and richer in significance. Because there is no mathematical connection between the topics, students have to study and recall an excessive number of distinct mathematical concepts and methods (NCTM 2000:275).

Learning is facilitated by the use of tools like books. According to Akbar (2013:33), a textbook can be defined as a publication that serves as a standard reference in a certain field. In order to be considered successful, the The creation of a good textbook requires taking into account not only how effective it is, but also how valid the information it contains. According to Akbar (2013:34), the following characteristics will be present in a book that is of high quality(8) high-readability textbooks with appropriate sentence length and structure. (1) correct spelling, terms, and sentence structure; (2) student-centered orientation; (3) communicative; (4) complete and systematic; (5) student-centered orientation; (6) side with national and state ideology; and (7) student-centered orientation.

The examination revealed that despite recent changes, the textbooks that are still being used at SMP Negeri 4 Tarutung have a number of faults that need to be corrected. The following are some examples of these deficiencies: (1) There is no concept map that is associated with the subject matter, and (2) the textbooks that are being used only contain ideas like subject-related theorems and formulae. (3) the language used in textbooks to explain concepts was still difficult for students to understand, and (4) textbooks lacked non-routine problems. All of these concerns added to students' confusion. Each difficulty contributed to pupils' inability to grasp the concept. Each Worry made students unable to comprehend the material.

Haggarty and Keynes (Muchayat, 2011: 201) explained that to improve mathematics teaching and learning in the classroom, teachers, students, and students must improve their understanding. This was stated in the article. The successful completion of learning goals is in large part dependent on the utilization of various learning instruments. To begin with the phenomenon that was addressed earlier, the substantial position that learning tools currently occupy can be seen as a result of this. the many different objects that are utilized for the purposes of education, as well as the interactions that take place between those things In order for the learning objectives to achieve good targets and because it is necessary to select appropriate learning methods and strategies, it is necessary to develop learning tools that are also in accordance with the learning methods and strategies that are being used. This is necessary because it is necessary to develop learning tools that are also in accordance with the learning methods and strategies that are being used. Creating learning tools that are not only compatible but also in line with the learning methods and strategies that are currently being implemented It is essential to develop learning tools that are also in line with the learning objectives methods and strategies that are being used It In addition to this, the development of educational tools is essential.

According to Trianto (2011), the problem-based learning paradigm requires students to work together in small groups with one another to find solutions to challenges that have been predetermined by both the students and the professors. This type of learning requires students to take more responsibility for their education. When the instructor puts into practice the learning paradigm, it's not uncommon for students to employ a wide range of different talents. In the instructional strategy known as problem-based learning, students are initially presented with various mathematical problems to work through. This is the beginning of the connection that may be made between problem-based learning and mathematical concepts. In order to attempt to find answers to issues that involve a variety of mathematical concepts, it is expected of students that they will use all of their abilities and knowledge. As part of problem-based learning, students take part in an investigation of their own choosing. This offers them the opportunity to interpret and explain a phenomena or problem while also improving their grasp of the subject matter. As a consequence of this, students are instructed at a level that is suitable for their aptitudes, which leads to a conditioned and controlled dynamic in which the interaction between teachers and students, as well as between students themselves, takes place. This is true both within the classroom and outside of it.

2 Method

This investigation has been categorized as Development Research based on the learning device development model proposed by Thiagarajan, Semmel, and Semmel, which is more commonly referred to as the 4-D model. Students who are currently enrolled in class VII at SMP Negeri 4 Tarutung, more specifically grades VII-A and VII-B for the 2021/2022 school year, were eligible to participate in this study and were chosen for participation based on a random selection process. The goal of this study was to design a teaching resource based on the Problem-Based Learning model, and it was successful in achieving that goal with the goal of improving students' algebraic knowledge and mathematical connection skills.

2.1 Data analysis

In order to determine the reliability of the educational resources, descriptive statistical analysis was performed, and the results were compared to the perspectives of five mathematical education specialists. On the basis of the judgment of the specialists, the value that each facet will have on average will be established, and then the average value of the entire set of features will be calculated.

When there is a high degree of congruence between the score on an item and the overall score, we say that the item has a high validity. This alignment may be examined using correlation, therefore in order to establish the item's reliability, the following formula for product moment correlation should be used can be utilized.

$$r_{XY} = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{((N \sum X^2 - (\sum X)^2)(N \sum Y^2 - (\sum Y)^2))}} \quad (\text{Arikunto, 2013: 89})$$

Even when the measurement is repeated on the same subject, the reliability of the testing instrument is evaluated to see whether or not the results obtained are consistent with one another. For the purpose of determining the degree to which each item on the examination may be relied upon, a formula known as

the Alpha-Cronbach formula is utilized. This formula is designed to mimic the format of an essay test (Arikunto, 2013).

Two observers who had been given the appropriate instruction in order for them to be able to appropriately operate the observation sheet on the implementation of the learning device watched the process of the learning device being put into action. The instruction had been given in order to ensure that the two observers could appropriately operate the observation sheet. The instruction had been provided in order to guarantee that both of the observers were capable of operating the observation sheet in the suitable manner. Carry out the procedures described on the sheet of observations regarding the operation of the educational tool. The implementation is presented in the form of two distinct choices, which are indicated by the words "yes" and "no" for each of the two options, respectively. In the case that you give an affirmative response to the enquiry, the following options will become open to you: The following choices are suitable in this situation: These options are as follows: (1) highly appropriate, (2) appropriate, (3) somewhat appropriate, (4) not appropriate, and (5) none of these alternatives are appropriate. The following options are appropriate: (1) highly suitable, (2) suitable, (3) somewhat suitable, (4) not suitable, and (5) none of these choices are appropriate. (1) very suitable, (2) suitable, (3) somewhat suitable, (4) not suitable, and (5) none of these options are suitable. (1) highly suitable; (2) suitable; (3) somewhat suitable; (4) not suitable; and (5) none of these options are suitable (5:very inappropriate).

The degree of mastery that can be achieved by students who participate in more conventional types of education is utilized as a measure for determining how effective educational materials are in terms of their capabilities to connect mathematical ideas. Analyzing The results of the posttests that the students took at the end of each class to evaluate their mathematical connection abilities allowed for the calculation of the percentage of students who were able to determine mathematical connections and comprehend the concept.. This was done by taking the data that was acquired and conducting the analysis on it. If a student gives the proper response to the comprehension question, then the student is considered to have understood the topic.

2.2 Data Collection Instruments and Techniques

The validity of the necessary learning materials and instruments was evaluated using each of the validation sheets that were included in this study. The PBM model necessitated the adaptation and modification of each of these validation sheets in order to meet its requirements. The validation sheet for the learning device is the tool that is utilized to collect information regarding the level of quality that the educational tool possesses as determined by the perspectives of a number of specialists in the relevant field. sheets of validation for the Learning Plans for implementation, worksheets for students, textbooks for students, and textbooks for teachers, in that order respectively.

Mathematical Connection Ability Test Instrument

The student's validation sheet for the mathematical connection ability test is divided into three sections: instructions, assessed aspects, and assessment conclusions. The sequence in which these sections are listed can be found up top. Examining a student's capacity for mathematical connection was approached from the perspective of three (three) different components, which are as follows: (1) the content; (2) the structure; and (3) the drafting of questions or assertions. It is possible to establish validity for the conclusions that were acquired from the assessment of the pupils' capability of making mathematical connections tests that were devised. Table 2 contains the instrument grid as well as the scores obtained from the mathematical connection ability test :

Table 2. Grid of mathematical connection ability test

No	Indicator	Question Number
1	Understand the connection of mathematical concepts with other mathematical concepts	1,2,3,4,5
2	Using mathematics in other fields of science	1,2,3,4,5
3	Using mathematics in daily life	1,2,3,4,5
4	Seeing mathematics as an integrated part	1,2,3,4,5

3 Results

3.1 Description of Learning Device Development Stage

According to the findings of It is evident, based on observations made at SMP Negeri 4 Tarutung as well as an analysis of learning tools that were carried out there, that teachers do not have access to adequate learning tools, and those tools are only occasionally utilized in the process of education. The existing plan for the application of learning does not involve any adjustments in the strategy that will be utilized to implement the learning.

Design Stage

Two observers who had been given the appropriate instruction in order for them to be able to appropriately witness the process of the learning device being put into action while you operate the observation sheet on the procedure. operate the observation sheet pertaining to the implementation of the learning device The implementation comes in the form of two different possibilities, each of which is denoted by the word "yes" or "no" correspondingly. If you respond "yes" to the question, you will be given the following options to choose from: (1) very suitable, (2) suitable, (3) somewhat suitable, (4) not suitable, and (5) none of these options are suitable. If you answer "no" to the question, you will not be given any of these options. (1) very suitable, (2) suitable, (3) slightly suitable, (4) not suitable, and (5) none of these options are suitable. (1) extremely suitable; (2) suitable; (3) somewhat suitable; (4) not suitable; and (5) none of these options are acceptable (5:very inappropriate).

The degree of mastery that can be acquired by students who participate in more conventional methods of education is utilized as a measure for measuring how effective educational materials are in terms of their skills to link mathematical ideas. Analyzing the posttest results of the students' mathematical connection abilities at the end of each class allowed for the calculation of the proportion of students who were able to determine mathematical connections.. Examining a candidate's ability to make mathematical connections using algebraic content and student disposition surveys are the two components that make up the test in question. Your capability to establish mathematical connections will be evaluated using a set of five questions that are in the form of descriptions. A total of one hundred and twenty minutes has been allotted for the completion of the examination.

There were a total of 32 statements in the questionnaire that the students were asked to fill out describing their mathematical disposition. These statements were designed to serve as indicators of independent learning. There were a total of 32 items, and five of those items discussed having interest and curiosity, five of those items discussed having self-confidence, seven of those items discussed being diligent and persistent, eleven of those items discussed having self-confidence, and nine of those items discussed evaluating the application of mathematics.

Development Stage

a) Expert Validation Results

The experts then validate the Preliminary Draft that was produced as a result. Validation by specialists was carried out across the board for all of the constructed implements. The resources that are provided to students include Lesson plans, LKPD, teacher books, and student books. Validation results, which are presented as alterations and recommendations, serve as the foundation upon which the learning device's development is based. The improved teaching tool that was created as a result of the validators' feedback is known as Draft-I.

b) Trial Results I

The validity of each pre-test and post-test item is evaluated using the formula for product moment correlation, and the findings are presented in the following format provided in Table 3. and Table 4. in the following format:

Table 3. Validity of Pre-test Items

No	r_{xy}	t_{count}	t_{table}	Interpretation
1	0.99	23.7	2.08	Valid
2	0.99	15.9	2.08	Valid
3	0.99	29.8	2.08	Valid
4	0.98	22.2	2.08	Valid
5	0.97	14.3	2.08	Valid

Table 4. Validity of Post-test Items

No	r_{xy}	t_{count}	t_{table}	Interpretation
1	0.99	27.9	2.08	Valid
2	0.99	29.9	2.08	Valid
3	0.99	30.8	2.08	Valid
4	0.98	20.8	2.08	Valid
5	0.97	18.3	2.08	Valid

According to the data in the table that can be found up above, all of the possible interpretations of the pre-test and post-test items fall into the category of having a high degree of validity. In light of the fact that the calculations for both the pre-test and the post-test were carried out manually and with the assistance of excel, it has been determined that each and every one of the items in question is appropriate for deployment.

Educators with years of experience working in the field of mathematics studies served as observers and monitored the process of putting into action all of the learning materials that were utilized in the research. Table 5, which can be found below, contains a recapitulation of the observations that were made in relation to the application of learning:

Table 5. Recapitulation of Observation Results on the Implementation of Learning Devices in Trial I

No.	Aspects Observed and Assessed	Meeting				Average	%
		I	II	III	IV		
1	The Learning Implementation Plan is going to be put into action.	3,50	4,00	4,50	5,00	4,25	85%

2	Worksheets for the Students' Use as an Implementation	3,50	4,50	4,50	4,50	4,25	85%
3	The Administration of the Instructor's Manual	3,50	4,00	4,50	4,50	4,12	82%
4	The actualization of the Student Handbook	3,50	4,00	4,50	4,50	4,12	82%
Average Execution		3,50	4,12	4,50	4,62	4,18	
Percentage of Execution		70%	82%	90%	92%	84%	

Table 5 shows that the average application of the learning tools produced during Trial I was 70% at the first meeting, 82% at the second, 90% at the third, and 92% at the fourth. First, second, third, and fourth meetings had these percentages. Four meetings yielded these results. The four sessions implemented 84% of the total number of learning tools.

Table 6 presents the results of the first test, which tested students' ability to make mathematical relationships.

Table 6. Description of Students' Mathematical Connection Ability Results in Trial I

Information	Pretest Mathematical Connection Ability	Posttest Mathematical Connection Ability
The highest score	80	95
Lowest Value	45	60
Average	62,25	77,75

According to the findings of the students' pre-tests, which are presented in Table 6, it can be seen that their post-test abilities resulted in an average mathematical connection ability of 77.75. In addition, the outcomes of pupils' classical mastery of their mathematical connection abilities on their very first attempt are presented in Table 7. below:

Table 7. Classical Completeness Level of Students' Mathematical Connection Ability in Trial I

Category	Pretest	Classical Completeness Percentage	Posttest	Classical Completeness Percentage
	Total students		Total students	
Complete	4	20%	14	70%
Not Complete	16	80%	6	30%
Amount	20	100%	20	100%

According the light of the facts presented in Table 7: It is evident that the students' mathematical connection abilities in the pre-test trial only possessed a classical completeness of 20 percent, but that this percentage increased to 70 percent in the post-test trial. As a result, one may arrive at the conclusion that the application of the problem-based learning model learning device that was generated did not match the requirements conditions necessary to achieve classical completeness in Trial I.

a) Result Trial II

The following table, number 8, provides a recapitulation of the observations that were made in relation to the application of learning

Table 8. Recapitulation of Observations on the Implementation of Learning Devices in Trial II

No.	Meeting	Average	%
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	Aspects Observed and Assessed	I	II	III	IV		
1	The Learning Implementation Plan is going to be put into action.	4,00	4,00	4,50	4,50	4,25	85%
2	Worksheets for the Students' Use as an Implementation	4,00	4,50	4,50	5,00	4,50	90%
3	The Administration of the Instructor's Manual	4,00	4,50	4,50	5,00	4,50	90%
4	The actualization of the Student Handbook	4,00	4,00	4,50	4,50	4,25	85%
Average Execution		4,00	4,25	4,50	4,75	4,38	
Percentage of Execution		80%	85%	90%	95%	87%	

Table 8 shows that the average implementation of the learning tools developed during Trial I was 80% at the first meeting, 85% at the second, 90% at the third, and 95% at the fourth. First, second, third, and fourth meetings had these numbers. First, second, third, and fourth meetings had these results. In addition to this, the total amount of learning tools that were implemented as a result of the four sessions had an average value of 87 percent.

Table 9, provided below, provides a detailed explanation of the findings of the students' mathematical connection abilities with regard to the second test.

Table 9. Description of Students' Mathematical Connection Ability Results in Trial II

Information	Pretest Mathematical Connection Ability	Posttest Mathematical Connection Ability
The highest score	80	100
Lowest Value	50	65
Average	63,5	82,25

According to the data in Table 9, which compares the students' performance on the pre- and post-tests, the students' average mathematical connection ability increased from 63.5 to 82.25 points.

In addition, Table 10 presents the results of the second trial of students' mathematical connection abilities, which can be considered as an indication of their level of classical mastery:

Table 10. Classical Completeness Level of Students' Mathematical Connection Ability in Trial II

Category	Pretest	Classical Completeness Percentage	Posttest	Classical Completeness Percentage
	Total students		Total students	
Complete	5	25%	18	90%
Not Complete	15	75%	2	10%
Amount	20	100%	20	100%

Table 10 demonstrates that students' levels of classical mastery of their mathematical connection abilities during the pretest trial II were only 25%, but during the posttest trial II, those levels increased to 90%. It is required that at least 85 percent of students who take the test on their ability to make mathematical connections receive a score of 75 or higher in order to fulfill the learning outcomes for classical pupils. The results of the posttest for the students' mathematical connecting abilities met the traditional standards for mastery because they got at least 90 percent correct. In the second test, the problem-based learning model's learning tools were successful in meeting the requirements for classically achieving acknowledged mastery levels.

3.2 Improving Students' Mathematical Connection Ability

The research that compared the results of improving students' connection abilities in trials I and II found that the average connection ability in the first trial's posttest results was 77.75, but it increased to 82.25 in the second trial. This was the finding of the research that compared the results of improving students' connection abilities in trials I and II. This was found out by comparing the posttest results of the two separate trials and looking for differences. These results are based on research that investigated the effect of teaching students connection skills in trials I and II on improving their performance could help them perform better overall. As a direct consequence of this, the kids' capacity to link increased by 4.5.

The utilization of educational technologies for problem-solving should result in increased connectedness. Mathematical connections can be improved through the application of a method known as "problem-based learning" since it helps students locate the problems and concepts. The duty of the teacher is to provide pupils with guidance and encourage them to think independently so that they might discover universal concepts. The instructor's questions and level of guidance depend on the students' present understanding and the topic being covered.

This is consistent with Rohaly and Abadi's (2019) research, which revealed that problem-based learning improves students' mathematical connecting ability. Researchers confirmed this. Problem-based learning increases mathematical connections, as can be seen.

4 Conclusion

Validation of learning media created with macromedia flash was deemed "valid" by the people who validated it. Learning media built with Macromedia Flash were able to meet the standards for practicability in terms of analyzing the application of learning. The initial experiment's learning implementation findings were "Implemented Less Well" and did not meet study standards. Despite this, the second trial of observing learning implementation was "Well Implemented."

Due to pre-trial adjustments. The created products meet the criterion for usefulness of learning media. The learning medium that makes use of Macromedia Flash has demonstrated that it satisfies the specified efficacy requirements in terms of the students' capacity for visual thinking, the ideal amount of time required to finish activities, and the typical responses given by students. The ability of the students to think visually was the basis for these criteria. utilizing educational tools that are supported by Macromedia Flash to improve students' visual thinking, as shown by the normalized gain index. First, "low" criteria increased value, then "mid" criteria increased value. Both results supported the idea.

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