Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.13, No.13, 2022

Development of Mathematics Learning Devices with Problem Based Learning Model to Improve Student's Mathematical Connection Ability

David Examen Sihombing, Mangaratua M. Simanjorang, Mulyono
Postgraduate Mathematics Education study program, Medan State University
Medan, North Sumatra, Indonesia
examensihombing88@gmail.com

Abstract
This study aims to: (1) analyze how the validity, practicality and effectiveness of learning tools developed through problem based learning models in algebra in class VII SMP Negeri 4 Tarutng; 2) analyze how to increase mathematical connection skills after using learning tools developed through algebraic material models in class VII SMP Negeri 4 Tarutung. This research is categorized into Development Research using the Thiagarajan, Semmel and Semmel learning device development model, namely the 4-D model (Four D Model). This research was conducted at SMP Negeri 4 Tarutung which is one of the junior high schools in Tapanuli Regency, North Sumatra Province. The subjects in this study were grade VII students of SMP Negeri 4 Tarutung, namely grades VII-A and VII-B in the 2021/2022 academic year. The results of the study show that: (1) learning devices with Problem Based Learning are included in the valid, practical and effective categories; (2) The improvement of students' mathematical connection abilities after using the problem based learning model on algebraic material based on the average achievement of students' mathematical connection abilities based on the posttest results of the first trial was 77.75, increasing to 82.25 in the second trial. Thus, there was an increase in the average score of students' connection abilities of 4.5.
Keywords: Development of learning tools, Problem Based Learning, mathematical connection ability
DOI: 10.7176/JEP/13-13-05
Publication date: May 31st 2022

INTRODUCTION

Mathematics is one of the subjects taught at every level of education, starting from early childhood education to the university level. Mathematics is a tool or mindset in connecting knowledge with the problem so that it can be resolved, both its applied aspects and its reasoning aspects, has an important role in efforts to master science and technology. For this reason, school mathematics needs to function as a vehicle to develop intelligence, abilities, skills and to shape the personality of students. Because in the process of learning mathematics there is a thinking process, because in thinking people make relationships between parts of information that have been recorded in their minds as meanings.

Mathematics education has two major objectives which include (1) formal goals, which emphasize the arrangement of children's reasoning and personal formation of students and (2) material goals that emphasize the application of mathematics and mathematical skills, namely the ability to solve mathematical problems. . This is in accordance with the objectives of learning mathematics formulated by the National Council of Teachers of Mathematics (NCTM, 2000), namely: (1) learning to communicate (mathematical communication); (2) learn to reason (mathematical reasoning); (3) learning to solve problems (mathematical problem solving); (4) learn to link ideas (mathematical connections); (5) the formation of positive attitudes toward mathematics (positive attitudes toward mathematics).

In fact, the quality of mathematics education is still low and must be improved. In other cases, there are still many teachers who still adhere to the old paradigm known as the transfer of knowledge in today's mathematics learning.

This is evidenced by the low achievement of Indonesian students in mathematics at the international level. This can be seen from the results obtained by Indonesia on TIMSS (Trends in International Mathematics Science Study) and PISA (Program for International Student Assessment) with an average international score = 500 and standard deviation = 100, summarized in the following table:

Table 1. PISA and TIMSS . Result Data

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

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

The low quality of education as mentioned above must be corrected, because mathematics is a basic science that is useful in everyday life. In addition, a nation that wants to be able to master science and technology well needs to prepare personnel who have sufficient knowledge of mathematics. One of the students' mathematical abilities that is very important to be developed among students is the ability of mathematical connections. This is based on the interrelationship of concepts or principles in mathematics. Mathematical connections are inspired because mathematics is not partitioned into separate topics but mathematics is a unified, hierarchical in its delivery and understanding. In addition, mathematics is not separated from other sciences and in everyday life.

The ability of mathematical connections makes it easier for students to understand the relationship between mathematical concepts and other mathematical concepts. With that knowledge, students understand mathematics thoroughly and more deeply. In addition, in memorizing, there will be less and less as a result learning mathematics becomes easier and more meaningful. Without a mathematical connection, students have to learn and remember too many separate mathematical concepts and procedures (NCTM 2000:275).

Books are tools that support learning. Akbar (2013:33) defines textbooks as textbooks that are used as standard references in certain subjects. The development of a good textbook must meet the criteria of being valid and effective. According to Akbar (2013:34) a good book is (1) accurate (accuracy); (2) appropriate (relevance); (3) communicative; (4) complete and systematic; (5) student-centered orientation; (6) side with the ideology of the nation and state, (7) the rules of correct language, textbooks written using correct spelling, terms and sentence structure; (8) legible, high readability textbooks contain sentence length and sentence structure according to the reader's understanding.

From the observations, the textbooks used at SMP Negeri 4 Tarutung still have several weaknesses, namely: (1) there is no concept map related to the material, (2) the textbooks used only contain concepts such as theorems and formulas that are directly related to the material. served to students without a scientific discovery process which resulted in the concept being meaningless for students, (3) the language used in textbooks to inform the concepts given was still difficult for students to understand, and (4) there was still a lack of presentation of non-routine problems in textbooks.

Starting from the above phenomenon, learning tools occupy an important position in achieving learning objectives, as explained by Haggarty and Keynes (Muchayat, 2011: 201) that in order to improve teaching and learning mathematics in the classroom, efforts are needed to improve the understanding of teachers, students, and students. materials used for learning and the interaction between them. In order for the learning objectives to achieve good targets, and the need for the selection of appropriate learning methods and strategies, it is also necessary to develop learning tools that are also in accordance with the learning methods and strategies used.

According to Trianto (2011) in the problem-based learning model, small groups of students work together to solve problems that have been agreed upon by students and teachers. When the teacher is applying the learning model, students often use a variety of skills. The relationship between problem-based learning and mathematics is a learning approach that begins with exposing students to mathematical problems. With all their knowledge and abilities, students are required to solve problems that are rich in mathematical concepts. Problem-based learning involves students in an investigation of their own choice which enables them to interpret and explain a phenomenon or problem and build their understanding of that phenomenon. Thus, learning takes place according to the ability of students, so that the interaction between teachers and students, as well as students and students becomes conditioned and controlled.

METHOD

Research Pattern

This research is categorized into Development Research using the Thiagarajan, Semmel and Semmel learning device development model, namely the 4-D model (Four D Model).

Subject

The subjects in this study were class VII students of SMP Negeri 4 Tarutung, namely grades VII-A and VII-B for the academic year 2021/2022, while the object in this study was a learning device based on the Problem Based Learning model on Algebra material and mathematical connection ability.

Data analysis

Analysis of the Validity of Learning Devices

To see the validity of the learning tools used descriptive statistical analysis and based on the opinions of five experts in the field of mathematics education. Based on the expert opinion, the average value for each aspect will be determined, so that the average value of the total aspects is obtained.

Analysis of the Validity and Reliability of Question Items

An item has high validity if the score on the item has a high alignment with the total score. This alignment can be interpreted by correlation, so to determine the validity of the item, the product moment correlation formula can be used as follows.

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

Information:

rxy = correlation coefficient between item score and total score
X = item score
Y = total score
N = number of students who took the test (sample))

The reliability of the test instrument is used to see the alignment of the results obtained even though the measurement is repeated on the same subject. To calculate the reliability of the test items, a formula that is in accordance with the form of an essay test is used, namely the Alpha-Cronbach formula (Arikunto, 2013).

Data Analysis of Practicality of Learning Devices

The implementation of the learning device was observed by two observers who had been trained so that they could operate the observation sheet on the implementation of the learning device correctly. The implementation is in the form of 2 (two) choices, namely yes and no. If you choose yes then there are 5 (five) choices, namely: (1: very appropriate); (2: appropriate); (3: quite appropriate); (4: not suitable); and (5:very inappropriate).

Data Analysis of Learning Device Effectiveness

The effectiveness of learning tools related to mathematical connection abilities is determined based on the achievement of classical student learning mastery. The data obtained from the posttest results of students' mathematical connection abilities at the end of each lesson were analyzed to determine the percentage of students who have been able to understand the concept. Each student is said to have been able to understand the concept if the student's correct answer is ≥ 75.

Data Collection Instruments and Techniques

Learning Tool Validation Sheet

All validation sheets in this study were used to measure the validity of the learning tools and instruments needed. All of these validation sheets were adapted and modified according to the needs of the PBM model. The learning device validation sheet is used to obtain data about the quality of the learning device based on the assessment of the experts. Validation sheets for Learning Implementation Plans, Student Worksheets, Student Books, and Teacher Books.

Test Instrument Validation Sheet

a) Mathematical Connection Ability Test Instrument

The student's mathematical connection ability test validation sheet consists of three (3) components, namely instructions, assessed aspects, and assessment results. The assessment of the validity of the student's mathematical connection ability test developed in terms of 3 (three) aspects, namely: (1) content; (2) construction; (3) writing questions/statements. The results of the assessment of the students' mathematical connection ability tests that were developed were valid. The instrument grid and the scoring of the mathematical connection ability test are in Table 2. :

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

RESULTS AND DISCUSSION

Description of Learning Device Development Stage

Defining Stage

Based on the results of observations and analysis of learning tools at SMP Negeri 4 Tarutung, it shows that teachers do not have appropriate learning tools and are rarely used in the learning process. The existing learning implementation plan (RPP) does not contain any updates in the method used.

Design Stage

The basis of the preparation of the test is task analysis and concept analysis described in the specification of learning objectives. The test in question is a test of mathematical connection abilities on algebraic material and student disposition questionnaires. The mathematical connection ability test consists of 5 questions in the form of a description. The time allotted to complete the test is 60 minutes.

The students' mathematical disposition questionnaire was in the form of 32 statements that matched the indicators of independent learning. Of the 32 statements consisting of 11 statements of self-confidence, 7 statements of diligent and persistent aspects, 5 statements of having interest and curiosity and 9 statements of assessing the application of mathematics. Each statement consists of 4 answer choices, namely SS (Strongly Agree), S (Agree), TS (Disagree) and STS (Strongly Disagree). The preparation of this questionnaire includes: grid design, statement items, and scoring guidelines.

Development Stage

a) Expert Validation Results

The resulting Preliminary Draft is validated by experts. Expert validation was carried out covering all developed devices. The tools consist of lesson plans, LKPD, teacher books, student books, and students' mathematical connection ability tests. The results of expert validation in the form of corrections and suggestions are used as the basis for making improvements to the learning device. The revised learning tool based on input from the validators is called Draft-I.

b) Trial Results I

Based on the product moment correlation formula, the validity of each pre-test and post-test items is obtained which is presented in Table 3. and Table 4. as follows:

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

Based on the data in the table above, the interpretation of each pre-test and post-test items is in the very valid category. Thus, based on calculations performed manually and excel, it is concluded that all the pre-test and post-test items can be said to be suitable for use.

The implementation of all learning tools used in the study was observed by observers who are teachers in the field of mathematics studies. The recapitulation of observations related to the implementation of learning can be seen in Table 5. below:

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	Implementation of the Learning Implementation Plan	3,50	4,00	4,50	5,00	4,25	85%
2	Implementation of Student Worksheets	3,50	4,50	4,50	4,50	4,25	85%
3	Implementation of Teacher's Book	3,50	4,00	4,50	4,50	4,12	82%
4	Implementation of Student Book	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%	

Based on Table 5. it is found that the average implementation of the learning tools developed in Trial I at the first meeting was 70%, for the second meeting it was 82%, for the third meeting it was 90% and for the fourth meeting it was 92%. Furthermore, the average value of the total implementation of learning tools from the four meetings was 84%.

The description of the results of students' mathematical connection abilities in the first trial is shown in Table 6. below.

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

Based on Table 6. shows that the average mathematical connection ability of students on the results of the pretests is 62.25 and the posttests is 77.75. Furthermore, the results of classical mastery of students' mathematical connection abilities in the first try can be seen 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%

Based on the data in Table 7. it can be seen that the classical completeness of the results of students' mathematical connection abilities in the pretest trial I was 20% while in the posttest trial I was 70%. So it can be concluded that in Trial I the application of the problem-based learning model learning device developed did not meet the criteria for achieving classical completeness.

b) Result Trial II

The recapitulation of observations related to the implementation of learning can be seen in Table 8. below:

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

No.	Aspects Observed and Assessed	Meeting				Average	%
		I	II	III	IV		
1	Implementation of the Learning Implementation Plan	4,00	4,00	4,50	4,50	4,25	85%
2	Implementation of Student Worksheets	4,00	4,50	4,50	5,00	4,50	90%
3	Implementation of Teacher's Book	4,00	4,50	4,50	5,00	4,50	90%
4	Implementation of Student Book	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%	

Based on Table 8. it is found that the average implementation of the learning tools developed in Trial I at the first meeting was 80%, for the second meeting it was 85%, for the third meeting it was 90% and for the fourth meeting it was 95%. Furthermore, the average value of the total implementation of learning tools from the four meetings was 87%.

The description of the results of students' mathematical connection abilities in the second trial is shown in Table 9. below.

Tabel 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

Based on Table 9. shows that the average mathematical connection ability of students on the results of the pretests is 63.5 and the posttests is 82.25.

Furthermore, the results of classical mastery of students' mathematical connection abilities in the second trial can be seen in Table 10. following:

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

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

Based on the data in Table 10, it can be seen that the classical mastery of the results of students' mathematical connection abilities in the pretest trial II was 25% while in the posttest trial II it was 90%. In accordance with the criteria for mastery of classical student learning outcomes, at least 85% of students who take the mathematical connection ability test are able to achieve a score of 75. Thus, the posttest results of students' mathematical connection abilities have met classical mastery because they obtained a percentage of completeness of 90%. So it can be concluded that in the second trial the application of the problem-based learning model learning tools developed has met the criteria for achieving mastery classically.

Improving Students' Mathematical Connection Ability

Based on the results of the analysis of improving students' connection skills in trials I and II, it shows that the average connection ability in the posttest results of the first trial is 77.75, increasing to 82.25 in the second trial. Thus, there was an increase in the average value of students' connection abilities by 4.5.

It is natural that there is an increase in connection capabilities by using learning tools with problem based learning models. This is because learning with a problem based learning model will improve students' mathematical connection skills because students themselves find the problems and concepts, while the teacher's role is to guide students by giving directions (guided) and students are encouraged to think for themselves so they can find general principles based on direction. The questions given by the teacher and to what extent students are guided depend on their abilities and the material being studied.

This is in line with the results of Rohaly and Abadi's research (2019) where the research results show that the achievement and improvement of students' mathematical connection abilities who receive learning using problem based learning models are better than students who receive ordinary learning. It can also be seen that learning with problem based learning models is very effective in improving mathematical connection skills.

CONCLUSION

1. The validation of learning media assisted by macromedia flash that was developed was in the "valid" category in terms of the analysis of the results of the validity of the learning media by the validators.
2. Macromedia flash-assisted learning media that was developed met the criteria for the practicality of learning media in terms of the analysis of the results of observing the implementation of learning. The results of the observation on the implementation of learning in the first trial were in the category of "Implemented Less Well" and did not meet the criteria for research success. However, after making several revisions, in the second trial the results of the observation of the implementation of learning were in the "Well Implemented" category. So that the learning media developed successfully met the criteria for the practicality of learning media.
3. The macromedia flash-assisted learning media that has been developed has met the established effectiveness criteria in terms of the results of the achievement of students' visual thinking abilities, the average percentage of students' ideal time achievement of activities, and the average student responses.
4. Improving students' visual thinking skills using macromedia flash-assisted learning media which was developed on cube and block material seen from the normalized gain index. It was found that in the first trial there was an increase in the value with the "low" criteria and in the second trial there was an increase in

the value with the "medium" criterion.

REFERENCES

Akbar, S. (2013). *Instrumen Perangkat Pembelajaran*. PT. Remaja Roskadarya.

Arikunto, S. 2013. *Prosedur Penelitian Suatu Pendekatan Praktek*. Jakarta: PT. Rineka Cipta

Muchayat. 2011. Pengembangan Perangkat Pembelajaran Matematika Dengan Strategi Ideal Problem Solving Bermuatan Pendidikan Karakter. *Jurnal PP Volume* 1, No. 2

NCTM. 2000. *Principles and Standards For School Mathematics*. ISBN : 0-87353-480-8. America : The United State Of America

Rohaly, F., & Abadi, A.P. (2019). Penerapan Model Problem Based Learning untuk Meningkatkan Kemampuan Koneksi Matematis Siswa SMP. Prosiding Sesiomadika, 1(1b)

Suherman, Erman dkk. 2003. *Strategi Pembelajaran Matematika Kontemporer*. Bandung: PT Remaja Rosdakarya.

Trianto. (2011). Model Pembelajaran Terpadu Konsep, Strategi dan Implementasinya dalam Kurikulum Tingkat Satuan Pendidikan (KTSP). Bumi Aksara

Trianto. 2013. *Mendesain Model Pembelajaran Inovatif-Progresif : Konsep, Landasan dan Implementasinya Pada Kurikulum Tingkat Satuan Pendidikan (KTSP)*. Jakarta : PT Kencana Prenada Media Grup