

Research Article

Development of Mathematical Logic Pipeline Tools (Pilogmath) for Learning Mathematical on Logic Material

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ABSTRACT

This development research aims to determine the feasibility of using Mathematical Logic Pipe teaching aid (Pilogmath) on mathematical logic material at SMA Negeri 1 Tanah Luas in terms of validity, practicality, and attractiveness. The development model used is the ADDIE development model which consists of the stages of analysis (*analysis*), design (*design*), development (*development*), implementation (*implementation*), evaluation (*evaluation*). The subjects of this research are class X SMA Negeri 1 Tanah Luas. The feasibility of learning media refers to the results of the assessment of teaching aids by experts, teachers and small group students. Feasibility can be seen from the results of the validator's assessment where all validators stated very valid, the results of the percentage of product ratings by media experts were 81% in the "Very Valid" category, the results of the percentage of product ratings by material experts were 87% in the "Very Valid" category, the results of the percentage of product assessment by the teacher were 92% in the "Very Practical" category, and the results of the percentage of product assessment by 6 small group students were 93.6% in the "Very Interesting" category. Based on product assessment by all validators who stated that it was very valid, the teachers assessment stated that it was very practical, and student assessment stated that it was very interesting, the Mathematical Logic Pipe teaching aid (Pilogmath) that was developed meeting the criteria of being very feasible to use for class X students of SMA Negeri 1 Tanah Luas.

Keywords: Teaching and Learning; Mathematics; Logic Mathematics; Logic; Pilogmath

1. INTRODUCTION

Over time, the development of science and technology is now increasingly rapid and sophisticated. For this reason, it is necessary to respond with professional and high-quality educational performance so that it can produce resources that are able to compete in the world of education. According to Rusmi (2019: 1) education is one of the supporting factors for increasing human resources. According to Law no. 20 of 2003 concerning the National Education System in article 1 states that education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to have religious spiritual strength, self-control, personality, intelligence, noble morals, and the necessary skills. himself, society, develop all the potential of students through the learning process. Meanwhile, according to Adhkar (2016:2) education is one of the main instruments in developing resources with multiple cognitive, affective and psychomotor abilities. Therefore, the implementation of education requires planning, implementation, as well as qualified and high-quality teaching staff so that the progress of a nation is expected to be achieved optimally.

According to Law no. 14 of 2005 concerning Teachers and Lecturers, Teachers are professional educators who have the task of educating, teaching, guiding, directing, training, assessing and evaluating students. In other words, the progress of a nation is determined by the educational staff and the level of knowledge developed in the lives of citizens. One of the knowledge possessed by humans is scientific knowledge or commonly referred to as science. Mathematics is one of the sciences that must be studied because it can be applied and can help people on a daily basis (Nurhairunnisah, 2017:3). In general, mathematics is a field of study that has an important position in the world of education. In fact, in every school, especially high school (SMA), one of the subjects taken is mathematics. Mathematical science is the science of understanding relating to numbers obtained by reasoning. This reasoning takes the form of logical reasoning and as an aid in interpreting various ideas and conclusions (Astuti, 2015: 105). Material related to logic is mathematical logic material.

Mathematical logic material is a very important subject of mathematics at high school level. Basically, the main goal of learning mathematical logic is to develop logical thinking patterns in dealing with everyday life problems. In fact,

mathematical logic material is the material with the least amount of mathematical calculations, however, many students still experience difficulties because mathematics lessons have abstract concepts and are not easily connected to everyday events in human life. Learning mathematics is related to understanding the concepts studied. The ability to understand concepts is very important for students to have as a basis for solving various mathematical problems. However, currently, the low ability to understand mathematical concepts is one of the problems faced in the world of education, especially education in Indonesia. The low understanding of students' concepts is caused by the poor quality of the learning process. This can be seen from the description of the results of the 2007 TIMSS study in research (Aziz, 2018:2) that Indonesian students' achievements in mathematics are still below the international average score. The achievement score for Indonesian children in mathematics is 405, while the international average score is 500. The achievement ranking for Indonesian children in mathematics is 36th out of 49 participating countries.

This is also proven by the results of observations made by researchers at SMA Negeri 1 Tanah Luas when conducting Field Experience Practices (PPL). when the learning process is ongoing, especially in mathematical logic material, the results of observations show that there are several problems including: 1) Students at the school still do not understand the concept of mathematical logic material due to the students' lack of attention, lack of concentration so they are sleepy, lazy to read , daydreaming, and busy alone. 2) Students make mistakes when solving questions. The following is the answer from one of the students who was given the question:

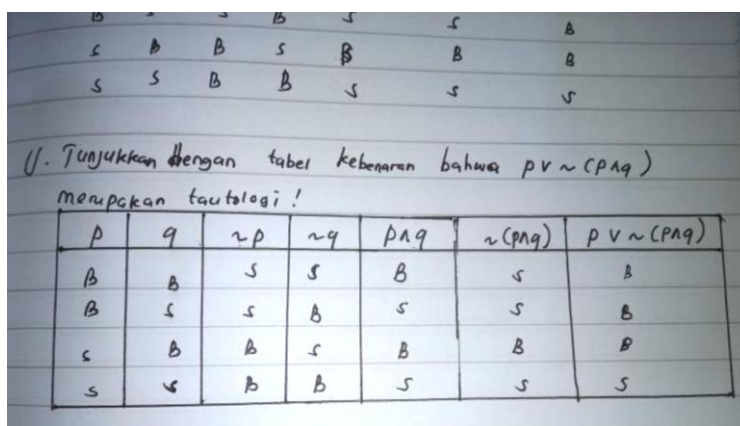


Figure 1. Results of Student Answers on Mathematical Logic Material

Based on the answers given by the students above, it can be seen that there is a lack of understanding of students' concepts in mathematical logic material. For this reason, mathematics lessons must be designed in such a way through learning media so that students can more easily understand concepts and are interested in studying mathematics. Students' low understanding of concepts can also be caused by the lack of use of interesting and varied learning media. Until now, the mathematical logic material taught at SMA Negeri 1 Tanah Luas has only used very limited textbooks. This media has not been able to optimally direct students' attention to learning, resulting in students being passive and lazy about learning.

In teaching and learning activities, students need something that allows good interaction with teachers, friends and their surroundings. The need for guidance, assistance, and teacher attention is different for each individual and group of students. To create an atmosphere that fosters enthusiasm for learning and student achievement, they need good learning arrangements. Murdiyanto (2014:1) states that in a teaching and learning process, there are two very important elements, namely teaching methods and learning media. These two things are very closely related, where the choice of a particular teaching method will influence the media or teaching aids used. The choice of media is made by the teacher based on the content of the material and the lesson methods used in order to provide appropriate knowledge and be easy to understand. One of the learning media is teaching aids. If we look at their function, teaching aids are tools that are used to demonstrate learning material so that the message conveyed is easier to understand (Uskono, 2019:23). From this explanation, we can understand that the role of teachers and learning media is very important in determining student success.

In connection with this problem, it is necessary to develop a simple mathematics teaching aid as a learning medium. It is important to carry out development research in the form of R&D (Research and development) to develop teaching aids to support the learning process. Prospective teachers should be able to create interesting situations and motivate students to be more enthusiastic and interested in learning using interesting tools so that students can understand the theory

presented. So it is necessary to develop new interactive learning media that are easy to make, cheap, and require little time but the results are effective and efficient in learning, especially in mathematical logic material. One of the teaching aids that can be used in mathematical logic material is the Mathematics Logic Pipe (Pilogmath).

The Mathematics Logic Pipe teaching aid is a teaching aid consisting of pipes connected in a rhombus shape and connecting channels. There are four forms in one medium with different names, namely conjunction, disjunction, implication and bimplication. Each end of the pipe is provided with a container to accommodate the inserted marbles. This teaching aid was created because it is in accordance with the Mathematical Logic material that will be explained, to make it easier for students to understand where formulas or concepts come from by experiencing them directly and connecting them with real objects and daily activities. This development is also based on research by Widyaningrum (2019) which states that the Pipe Logic Mathematics (Pilogmath) teaching aid is very suitable and interesting to use based on validation from media experts, material experts, teacher responses and student responses. This research by Widyaningrum was further strengthened by research conducted by Awaliyah (2018) which stated that the Pilogmath teaching aids met the criteria for being valid/suitable for use by students. Based on the results of several studies above, it can be concluded that one way to improve the quality of education and understanding of concepts in students is by developing teaching aids that are valid/suitable for use so that researchers intend to develop Mathematical Logic Pipe (Pilogmath) teaching aids.

Based on the explanation of the problem above, the researcher feels that the Mathematics Logic Pipe (Pilogmath) teaching aid can help clarify the mathematical concepts presented. So researchers are interested in conducting research with the title "Development of Mathematics Logic Pipeline Tools (Pilogmath) for Learning Mathematical Logic Material for Class X SMA". The formulation of the problem in this research is how is the feasibility of developing a Mathematical Logic Pipeline (Pilogma) teaching aid in mathematical logic material in class The aim of the development is to determine the feasibility of developing a Mathematical Logic Pipeline (Pilogma) teaching aid in mathematical logic material in class XI of SMA Negeri 1 Tanah Luas. seen in terms of validity, practicality and attractiveness.

2. RESEARCH METHOD

The research used in this research is Research and Development (R&D) research. According to Sugiono (2018: 297) Research and Development (R&D) is a research method used to produce certain products and test the effectiveness of these products. The product developed in this research is learning media. This research adapts the ADDIE development model which consists of five stages which include analysis, design, development, implementation and evaluation. The subjects in this research were class. Sugiono (2018: 297) said that research and development methods are research methods used to produce a particular product and test the effectiveness of the product. In this research, as previously explained, researchers used the Research and Development (R&D) method, which is a process or steps to develop an existing product or improve the product. The research design used in this research refers to Research and development (R & D), namely the ADDIE development model. The ADDIE development model consists of 5 stages, namely: Analysis, Design, Development, Implementation and Evaluation. The ADDIE model was developed by Dick and Carry in 1996 (in Mulyatiningsih: 184) to design learning systems. Below are examples of activities at each stage of developing a learning model or method. Development of Mathematics Logic Pipe teaching aids. The type of data used in this research is qualitative data. Data collection in this study used a validation sheet instrument in the form of a questionnaire using a Likert scale which was used to determine whether the instrument that had been designed was valid or not.

Table 1. Grid of Media Expert Validation Questionnaire

No.	Assessment aspects	No. question items	Number of questions
1	Accuracy of Props	1,2,3,4, 5,6	6
2	Aesthetics	7,8,9,10	4
3	Props Safety	11	1
4	Tool Durability	12,13,14,15	4
5	Practicality of Props	16, 17,18,19,20	5
Amount			20

(Source: Marcella (2017:54) modified by researcher)

Table 2. Material Expert Validation Questionnaire Grid

No.	Assessment aspects	Question number	Number of questions
1	The relationship between teaching aids and teaching materials	1,2,3,6,10,11,19,20,14,16,17	11
2	Educational value	4,8,9,13,15,18	6
3	Suitability of teaching aids with teaching materials	7,5,12	3
Amount			20

(Source: Marcella (2017:54) modified by researcher).

Table 3. Teachers' Response Questionnaire Grid

No.	Assessment aspects	Question item no	Number of questions
1	The relationship between teaching aids and teaching materials	1,2,3,17	4
2	Educational value	5,6,7,19,20	5
3	Props aesthetics	4,9,10,11,12	5
4	Accuracy of teaching aids	8,13,14,18	4
5	Security for students	15	1
6	Efficiency of teaching aids	16	1
Amount			20

(Source: Marcella (2017:56) modified by researcher)

Table 4. Students' Response Questionnaire Grid

No.	Assessment aspects	Question number	Number of questions
1	Accuracy of teaching aids	1,2,4,5,13,16	6
2	Motivation to learn and understanding the concept of mathematical logic material using teaching aids	3,6,7,8,9,10,11,12,14,15,17,18,19,20	14
Amount			20

(Source: (Marcella, 2017:56) modified by researcher).

To calculate the average value, you can use the following formula (Arikunto, 2017:301):

$$x = \frac{\sum fx}{N}$$

Information:

x = Average score

Σx = Total score

N = Number of values

3. RESULTS AND DISCUSSION

Results

This research aims to develop a mathematics logic pipeline teaching aid (Pilogmath) for learning mathematical logic material for class X SMA. The first stage of this development research was the analysis stage by making observations at SMA Negeri 1 Tanah Luas. The results of this analysis will be a reference in developing Mathematics Logic Pipeline teaching aids (Pilogmath) for learning mathematics logic material for class X SMA. The product was tested on students at SMA Negeri 1 Tanah Luas with a small group test consisting of 6 students. This test was carried out to determine the attractiveness of the Mathematics Logic Pipe (Pilogmath) teaching aid based on small group trials. The trial was carried out by giving students a questionnaire regarding the attractiveness of the Pipe Logic Mathematics (Pilogmath) props.

Table 5. Recapitulation of Student Response Test Results for Small Groups on the Mathematical Logic Pipeline Tool

No.	Respondents	Score	Ideal Score	Mean	%	Category
1.	A.M	94	100	4.7	94	Very interesting
2.	RSA	100	100	5	100	Very interesting
3.	R.A	100	100	5	100	Very interesting
4.	AAS	100	100	5	100	Very interesting
5.	RJ	87	100	4.35	87	Very interesting
6.	R	100	100	5	100	Very interesting
Amount		581	100	4.8416	96,833	Very interesting

Table 6. Recapitulation of Student Response Test Results for Large Groups on the Mathematical Logic Pipeline Tool (Pilogmath)

No.	Respondents	Score	Ideal Score	Mean	%	Category
1.	NA	91	100	4.55	91	Very interesting
2.	LF	94	100	4.7	94	Very interesting
3.	HNK	100	100	5	100	Very interesting
4.	PIM	91	100	4.5	91	Very interesting
5.	M.F.A	90	100	4.5	90	Very interesting
6.	RR	87	100	4.35	87	Very interesting
7.	FR	87	100	4.35	87	Very interesting
8.	H	92	100	4.6	92	Very interesting
9.	F	93	100	4.65	93	Very interesting
10.	DF	93	100	4.65	93	Very interesting
11.	H	97	100	4.85	97	Very interesting
12.	IR	100	100	5	100	Very interesting
13.	NI	95	100	4.75	95	Very interesting
14.	VK	98	100	4.9	98	Very interesting
15.	EY	100	100	5	100	Very interesting
16.	S.A	96	100	4.8	96	Very interesting
17.	N.F	91	100	4.55	91	Very interesting
18.	P.E	93	100	4.65	93	Very interesting
19.	WL	97	100	4.87	97	Very interesting
20.	SS	99	100	4.95	99	Very interesting
21.	RM	98	100	4.9	98	Very interesting
22.	K.K	99	100	4.95	99	Very interesting
23.	NS	71	100	3.55	71	Interesting
24.	F	99	100	4.95	99	Very interesting
25.	A	89	100	4.45	89	Very interesting
Amount		2340	100	4.6788	93.6	Very interesting

Based on **Table 6**, the results of large group trials with research subjects of 25 students obtained an average score of 4.6788 with a percentage of 93.6% categorized as "Very Interesting", judging from this data this means that the teaching aids developed by the author also has interesting criteria to be used as a learning medium for class of five stages which include analysis, design, development, implementation and evaluation.

Discussion

The first stage in this research and development was the analysis stage by conducting interviews at SMA Negeri 1 Tanah Luas by conducting curriculum analysis, student integrity analysis, and situation analysis. The material chosen in this research is mathematical logic. From the analysis stage it can be concluded that the lack of learning media results in weak understanding of students' concepts, so that it greatly influences students' interest in learning and student achievement

both inside and outside of school, so based on the results of the analysis a new media is needed that can visualize abstract material so that able to understand the concepts of mathematical logic material and be actively involved in the teaching and learning process. This is in line with the definition of learning media according to Kustandi (2011: 9) which states that learning media is a tool that can help the teaching and learning process and functions to clarify the meaning conveyed so that good and perfect learning goals can be achieved.

After obtaining information regarding the development of a product, it is continued with the planning stage. At this stage there are three steps to designing the media that will be developed, namely, designing a mathematical logic pipeline (Pilomath), preparing game rules, materials, and preparing assessment instruments. In the mathematical logic pipe teaching aid (Pilomath) there are 4 components that have different functions, at the bottom of the pipe a container is provided, for statements with a true value the marble will occupy the container, while for statements with a false value the marble will not occupy the container. Apart from product design and game rule design, at this stage research instruments were also prepared in the form of expert validation questionnaires, small group student validation questionnaires, and large group student validation questionnaires. A validation questionnaire is used to assess the feasibility of the development product. The third stage is the development stage, then the learning aids product is ready to be developed by the developer. At the development stage, researchers make products according to the designs that have been prepared at the design stage. After the teaching aids were ready to be developed, the researcher first provided guidance to the two supervisors. From the results of the guidance, the teaching aids were repaired once until finally they could be validated by experts and small groups of students. This validation was carried out to find out whether the teaching aid development product was suitable for use for mathematics learning in class X SMA Negeri 1 Tanah Luas.

Based on the analysis of product validation results by media experts, material experts and small group students carried out at the development stage, the validation results from media experts were 81% with very valid criteria, while for material experts it was 87% with very valid criteria. From the results of the average value and percentage obtained, it shows that the Pilomath teaching aid product developed is very feasible and can be used in the learning process in class X SMA Negeri 1 Tanah Luas. Then, on the product validation sheet, a place is provided for comments and suggestions or opinions from the validators. The validators provided the opinion that overall the Pilomath teaching aids developed were good, easy to understand and met the standards with several suggestions for improvement. In developing this teaching aid, there were several obstacles experienced, including: 1). The process of designing the mathematical logic pipe props (Pilomath) that will be developed takes a long time, taking everything into consideration, namely by designing the pipe pieces, so that they can be shaped according to what is needed. 2). The pipe attachment on the flannel is still not attached enough, so you have to pay attention to the thickness of the glue. After the Pilomath teaching aids were validated by validators and revised according to suggestions, the development product was tested in schools to determine the effectiveness of using the product. This trial was carried out at the implementation stage on a large group of students, namely all class X MIA 3 SMA Negeri 1 Tanah Luas students. This product trial was carried out to determine the effectiveness of the product being developed.

At this stage, a response questionnaire is given to teachers and students to assess the practicality and attractiveness of the product being developed. Based on the results of the teacher's responses, a score was obtained with a percentage of 92% in the very practical category, while for student responses a score was obtained with a percentage of 93.6% in the very interesting category. So based on the results of teacher and student responses, it can be said that the presence of media has an important role in the learning process, this is in line with the opinion of Rogness (2011) which states that the use of visualization can help students improve their understanding of concepts. Also supported by the opinion of Tafrilyanto (2015) who stated that the use of media makes students actively involved in learning activities and the material will be stored longer in students' brain memory so that it can support students' conceptual knowledge. Based on the Pipe Logic Mathematics (Pilomath) teaching aids that were developed, validation was carried out by material experts and media experts, then teacher and student response questionnaires were given as well as criticism and suggestions for the teaching aids that were developed. So, it can be concluded that the mathematics logic pipeline teaching aid (Pilomath) for learning mathematical logic material for class X SMA is worthy of development.

This is in line with Geme's research (2017) with research results that show the influence of understanding mathematical concepts using logic pipes on mathematical logic material at Tawa Tanah Kewapante Private Vocational School which states that there is an influence of learning media using logic pipe teaching aids on understanding mathematical concepts as seen from the average score. The average obtained in the experimental class with 25 students

was 69.4 with a standard deviation of 12.83. It can be concluded that using the teaching aids media model is more effective than the conventional model. And Rustandi's research (2021) shows that this research has succeeded in developing desktop-based learning media which was developed using PPT VBA and Parkol Videoscribe with the ADDIE development model, namely Analysis, Design, Development, Implementation, and Evaluation with a very suitable category for use with a feasibility percentage of 90 % by media experts and a percentage of 91% by material experts were declared very feasible.

The final stage is the evaluation stage, this stage is flexible because it can be used in all stages of the ADDIE model. Evaluation is carried out by researchers to evaluate needs analysis after pre-research is carried out at the analysis stage, then it is also used to evaluate the results of designs or designs initiated by the author. Evaluation is also really needed at the development stage, namely to evaluate the extent to which the product needs have been developed and also the validation results. From experts, the next evaluation plays a very important role at the implementation stage, namely to see not only the quality but also the attractiveness of the Pipe Logic Mathematics (Pilogmath) teaching aids which have been developed and tested on teachers and students of class X MIA 3 at SMA Negeri 1 Tanah Luas.

4. CONCLUSION

Based on the results of research that has been carried out in accordance with research procedures, it can be concluded that: (a) The development of mathematics teaching aids has been carried out in accordance with 5 steps, namely: Analysis, Design, Development, Implementation and Evaluation. b) The developed Mathematical Logic Pipeline (Pilogmath) teaching aid can help students in the mathematics learning process, especially mathematics lessons. In this research, the researcher only developed teaching aids to see the suitability of mathematics lecturers and mathematics teachers as validators for media experts and material experts, practical aspects for mathematics teachers, and attractiveness for students. (c) Based on the results of the questionnaire obtained, the total average score for media was 4.05 with a percentage of 81% categorized as "Very Appropriate" and the average score for material was 4.35 with a percentage of 87% categorized as "Very Appropriate". Then the results of product trials on teachers obtained an average score of 4.6 with a percentage of 92% categorized as "Very Practical", small group product trials obtained an average score of 4.8416 with a percentage of 96.833% categorized as "Very Interesting", and trials in the large group obtained an average score of 4.6788 with a percentage of 93.6% categorized as "Very Interesting". So, it can be stated that the PILOGMATH teaching aids are very suitable for use in mathematics subjects with mathematical logic material.

RECOMMENDATION

Based on the suggestions that researchers can give based on the research results, they are as follows: (1) To teachers, namely: (a) Development of learning media in the form of Mathematics Logic Pipe (Pilogmath) teaching aids for class X that can be used in the learning process. (b) Teachers can develop the Mathematical Logic Pipe (Pilogmath) teaching aids to make them look even better. (2). To further researchers, namely: (a) In further active research, researchers should be able to develop more innovative and creative learning media. (b) Conduct better research and maximize the development of Mathematical Logic Pipeline (Pilogmath) teaching aids to make them more effective and efficient, especially in the use of the tools used and required.

ONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

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