Development of Mathematics Learning Devices on Sequence-Arithmetic Topic with Problem Based Learning Model

Garry Wolf Wauran[1], Philoteus E. A. Tuerah[2], Anekke Pesik[3]

Master of Mathematics Education Study Program, Postgraduate Program, Manado State University, Indonesia
[1]garrywauran[at]gmail.com, [2]pheatuerah[at]unima.ac.id, [3]pesikanekke123[at]gmail.com

Abstract: ***This study aims to produce a valid, practical and effective learning tool to teach the topic 'Arithmetic Sequences in class X SMK. The learning tools in question include Learning Implementation Plans, Student Worksheets, and Learning Outcome Evaluation Instruments designed according to the Problem Based Learning model. This goal is achieved by conducting research on the development of the Thiagarajan model or what is known as the modified 4-D model. Modification of the model is done by eliminating the Disseminate Stage due to the limitations of the researcher in terms of time and finance. The results showed that the quality of the developed device met the aspects of validity in the 3rd round of assessment. The practicality and effectiveness of the developed device was achieved after the 2nd round of trials. These results indicate that the objectives of this development research have been achieved, namely that valid, practical and effective learning tools have been obtained to teach the Arithmetic-Sequence topic in high school class X.***

Keywords: Learning Tools, Development, Problem Based Learning, Arithmetic Sequences

1. Preliminary

In order to improve the quality of education in Indonesia, the government is continuously making changes to the implementation of the education curriculum in schools. Changes in the implementation of the curriculum were made in view of the Covid-19 pandemic which greatly affected the world of education, especially for the implementation of learning. During the Covid-19 pandemic, learning is carried out with the help of the internet network and also outside the network if possible. Learning that is not optimal, of course, results in a lack of student mastery of the subject matter taught, especially the topic of Arithmetic Sequences. Arithmetic Sequence is a mathematical concept that is widely used as the basis of other applied sciences so that it becomes one of the knowledge that plays an important role in developments in the 21st century. The failure of students to master important concepts from Arithmetic Sequences clearly does not only affect the scope of knowledge of these students, but will also affect his ability to apply knowledge in life and get practical benefits from that knowledge.

In studying Arithmetic Sequences, one of the learning models that are considered in accordance with the demands of the curriculum is the Problem-Based Learning (PBL) model. According to Arends (Trianto, 2010), PBL is a learning approach in which students are faced with authentic or real-world problems, so that they are expected to be able to construct their own knowledge, develop high-level skills and inquiry, make students independent, and increase their self-confidence.The syntax of the PBL model (Arends, 2007) consists of: (1) student orientation to problems; (2) Organizing students for learning; (3) Assist with independent and group investigations; (4) Develop and present the work, and (5) Analyze and evaluate the problem solving process. As a learning model, the PBL model has several advantages (Sanjaya, 2007), including: (1) Challenging students' abilities and providing satisfaction for students to discover new knowledge; (2) Increasing students' motivation and learning activities; (3) Assisting students in transferring students' knowledge to understand real world problems; (4) Helping students to develop their new knowledge and be responsible for the learning they do. In addition, the PBL model can encourage students to self-evaluate both the results and the learning process; (5) Develop students' ability to think critically and develop their ability to adapt to new knowledge; (6) Provide opportunities for students to apply the knowledge they have in the real world; (7) Develop students' interest in continuously learning even though studying in formal education has ended; (8) Facilitate students in mastering the concepts learned in order to solve world problems. The disadvantages of the PBL model (Sanjaya, 2007) are as follows: (1) When students do not have interest or do not have confidence that the problem being studied is difficult to solve, they will feel reluctant to try it; (2) For some students assume that without an understanding of the material needed to solve the problem why they should try to solve the problem being studied, then they will learn what they want to learn. To overcome the shortcomings of the PBL model, it is necessary to design learning activities properly accompanied by adequate preparation. For this reason, the researcher considers that it is necessary to develop a learning device based on the PBL model to teach the topic of Arithmetic Rows. The learning tools in question are Learning Implementation Plans (LIP), Student Worksheets (SW) and Learning Outcomes Evaluation Instruments (LOEI). Fitri, et al (2020) research on the development of 21st century skills integrated mathematics learning tools through the application of the PBL model, resulted in 21st century skills integrated mathematics learning tools, through the application of the PBL model to improve students' mathematical problem solving abilities in statistics material for class VIII SMP. Learning tools are said to be very valid, very practical and effective after going through a validation process by qualified experts, and class VIII students to ensure the practicality of the learning tools developed. Research by Yustianingsih, et al. (2017) regarding the development of problem-based learning-based mathematics learning tools to improve the problem-solving abilities of class VIII students. Based on the development process that has been carried out, the results obtained are valid, practical and effective learning tools to improve mathematical problem solving abilities and activities of Class VIII SMP students. Cahyono's research, (2017) regarding the development of learning tools with PBL models oriented to students' creative thinking skills and initiatives, obtained several conclusions, namely learning devices using achievement-oriented PBL models, creative thinking skills and student initiatives developed have met the valid, practical criteria. and effective. Kusumawati (2015) researched the development of project-based learning (PBL) mathematics learning tools to improve mathematical communication skills. Learning material for linear programming using PBL model learning tools succeeded in completing students' mathematical communication skills classically with a minimum proportion of 70% and individually exceeding the KKM 65 limit. Susanto, et al (2016) examined mathematics learning tools characterized by PBL to develop HOTS for high school students. The development research resulted in several conclusions, namely (1) mathematics learning device products with PBL characteristics to develop HOTS for high school students in class X semester 2 have the characteristics: (a) oriented to unstructured real problems, (b) systematically arranged based on PBL and scientific steps, and (c) developing student HOTS. (2) The final product of the learning device meets the criteria of validity with the average score of the validator's assessment in the valid category. (3) The final product of learning tools meets the practical criteria with the average teacher assessment in the very practical category and the average student assessment in the practical category. (4) The final product of the learning device meets the effective criteria as indicated by the percentage of classical completeness of the test subject more than 75%, which is 80% at SMAN 03 and 82.61% at SMAN 05 Mukomuko.

2. Research Procedure

The research applied is classified as a type of development research according to the 4-D model or the Thiagarajan model (Sinolungan, 2019). The 4-D research model consists of 4 stages, namely Define (defining), Design (design), Develop (development), and Disseminate (dissemination). Due to limited time and funds, the researcher made modifications (Trisna, 2006) with the limitation only reaching the Develop stage. Each stage consists of several cyclical activities. This means that each activity can be repeated if it does not meet Nieveen's (1999) criteria.The description of the development scheme is shown in **Figure-1**. Validity data was obtained through the assessment of experts and practitioners of mathematics education. Practicality data and effectiveness data were obtained through observation of trial activities and questionnaire distribution to students of State Vocational High School 1 Modoinding.

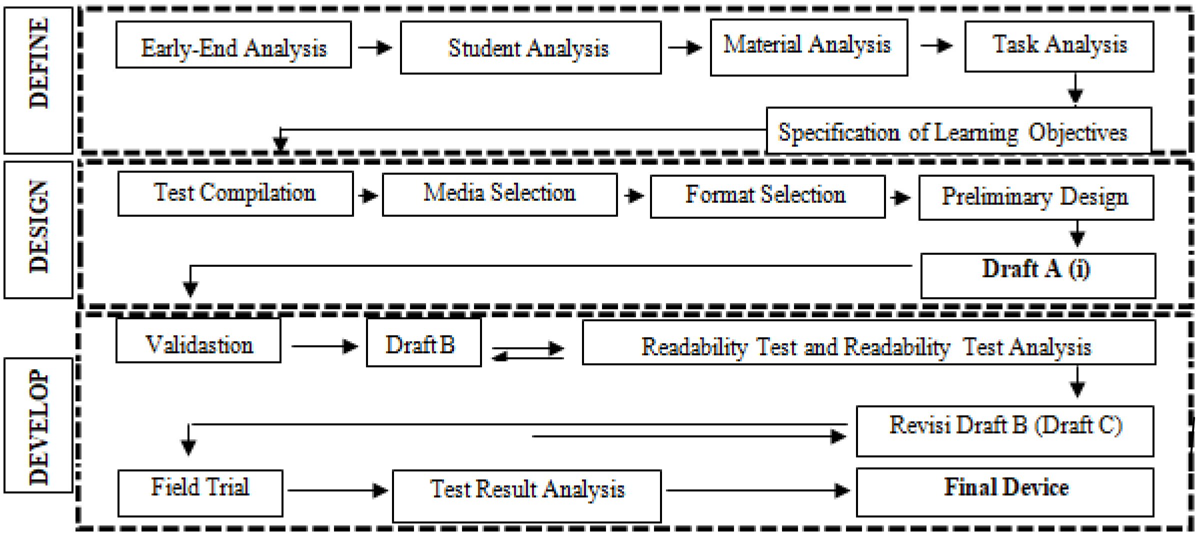

Figure 1: Description of the steps for Developing Learning Tools based on the 4-D model

3. Results and Discussion

The results obtained at the define stage which include preliminary and final analysis activities, student analysis, analysis of mathematical concepts/materials, task analysis, and specification of learning objectives, are that it is necessary to design and develop lesson plans, SW and mathematical LOE instruments, especially the *Arithmetic Sequence* topic in class X SMK.

Table 1: Analysis of LIP Validation Results

No	Assessment Aspect	Number of Items	Total value of 3 validators	Average	Criteria
1	Identity	8	120	5.00	Very good
2	Indicators and Learning Objectives	4	56	4,67	Very good
3	Material Selection	4	52	4,33	Very good
4	Selection of Approach and/or Learning Model	5	68	4,53	Very good
5	Suitability of Learning Activities with the PBL Model	8	97	4,04	Very good

6	Learning Resources & Assessment of Learning Outcomes	8	98	4,08	Very good
Average total score		37	491	4,44	Very good

The results obtained at the design stage which include media selection, format selection, and initial design are the LIP, SW and LOE mathematical instruments, especially the Arithmetic Sequence topic in class X SMK which is ready to be validated. The document is called Draft A(i) where i refers to the number of rounds of assessment by the validators until the LIP, SW and LOE instruments draft A documents are obtained that meet the valid requirements.The validator consisting of 3 (three) people gave a valid assessment of the draft A(i) after two rounds. In the first round as a whole, Draft A(1) did not meet the valid requirements. Researchers made revisions based on corrections and notes provided by the validators. After being reassessed by the validators, a Draft A(2) document that meets the valid requirements is obtained. The description of the results of the validators' assessment of the LIP, SW and LOE instruments in the second consecutive round is as follows. Analysis of the results of the assessment by 3 (three) validators of the draft A(2) LIP document can be seen in **Table 1**.

Table 2: Analysis of SW Validation Results

No	Assessment Aspect	Number of Items	Total value of 3 validators	Average	Criteria
1	SW Format format	7	91	4,33	Very good
2	Contents of SW	7	92	4,38	Very good
3	Language and Writing	5	66	4,40	Very good
4	Illustrations, Layouts of Tables and Diagrams/Images	4	49	3,58	Good
5	Benefits/ Uses of SW	2	27	4,50	Very good
Average Total Score		25	325	4,24	Good

Based on the results of data analysis in the table above, it can be seen that the draft document Draft A(2) of the LIP developed meets the minimum criteria in all aspects and the average total score of LIP validation from the three experts is 4.44 with very good criteria. Based on these criteria, it can be concluded that the designed lesson plans are in the valid category. Analysis of the results of the assessment by 3 (three) validators of the draft document Draft A(2) SW can be seen in **Table 2**.

Based on the results of data analysis in the table above, it can be seen that the draft document Draft A(2) of the SW developed meets the minimum criteria both in all aspects and the average total score for SW validation from the three experts is 4.20 with good criteria. Based on these criteria, it can be concluded that the SW developed is in the valid category. Analysis of the results of the assessment by 3 (three) validators on the draft document Draft A(2) of the LOE instrument can be seen in **Table 3**.

Table 3: Analysis of LOE instrument validation results

No	Assessment Aspect	Number of Items	Total value of 3 validators	Average	Criteria
1	Subject matter	4	51	4,25	Good
2	Construction	4	50	4,17	Good
3	Language	2	24	4,00	Good
Average total score		10	125	4,14	Good

Based on the results of data analysis in the table above, it can be seen that the draft document Draft A(2) of the developed LOE instrument meets the minimum criteria both in all aspects and the average total score of LOE validation from the three experts is 4.14 with good criteria.

Table 4: Analysis of Teacher Ability Results in Managing Learning

No	Aspect	Item	Pertemuan	
			I	**II**
1	Introduction	1	4	4
		2	5	5
		3	5	5
2	Core activities	4	4	4
		5	5	5
		6	4	4
		7	5	5
		8	5	5
		9	4	4
		10	5	5
		11	5	5
3	Closing	12	5	5
		13	4	4
		14	5	5
		15	5	5
4	Time Management	16	4	4
5	Class situation	17	4	5
		18	4	4
Average			4,56	4,61
Category			Very good	Very good

Based on these criteria, it can be concluded that the LOE instrument developed is in the valid category. Furthermore, the valid documents are referred to as Draft B(i) documents, where i refers to the number of trials carried out to obtain practicality and effectiveness data until the Draft B document is declared practical and effective.

The practicality data that was collected using an observation format was obtained through a field trial of the Draft B document. The results of the field trial of the Draft B document reached the practical category in the first and second field trials. The second field trial was carried out because the effectiveness category in the first field trial had not yet reached the specified criteria. The description of practical data analysis with indicators of the teacher's ability to manage learning using the Draft B(i) learning tool in the first and second trials can be seen in **Table 4**.

Based on the results of the analysis, the teacher's ability to manage learning at the first and second meetings reached the very good category. This learning device has not been revised based on the observations of the teacher's ability to manage learning. Based on the results of the analysis, the

Draft B document is in the practical category. Effectiveness data which includes student learning outcomes data captured with the LOE instrument and student response data collected using a questionnaire instrument, were obtained through field trials on the Draft B document.

Table 5: Analysis of Student Learning Outcomes in the Second Trial

Number of Students	Number of Completed Students	Completeness Percentage	Number of Unfinished Students	Percentage of Incompleteness
24	21	87,50%	3	12,50%

The results of the field trial on the Draft B document reaching the effective category occurred in the second field trial. It should be reported that the field validity requirements and the reliability requirements of the LOE instrument were achieved in the first round of field trials, so that an analysis of students' learning mastery could be carried out. The description of the second effectiveness data analysis can be seen in **Table 5** and **Table 6**.

Based on the results of the analysis in **Table 5**, it can be concluded that in the second field trial, the criteria for mastery of student learning outcomes have been achieved. After the implementation of the second field trial, the researchers distributed questionnaires to students who took part in the learning in the second trial, and the data and analysis results are shown in **Table 6**.Based on the results of the questionnaire data analysis of student responses to the implementation of learning in the second Trial, the percentage results obtained in each questionnaire category where more than 80% gave a positive response to the implementation of learning that applies the device being developed. With the results of data analysis on learning outcomes that meet the criteria for completeness and the results of data analysis on positive student responses, the researchers conclude that the learning tools developed are in the effective category.

Based on the results of the research presented above, the learning tools consisting of lesson plans, SW, and the resulting LOE instrument include quality criteria and meet eligibility in terms of validity, practicality, and effectiveness. The procedure carried out in developing and producing learning tools that are valid, practical and effective through several stages, starting from the defining, Design and Development stages.

Table 6: Student Responses to Learning Devices and Implementation

No	Aspects Responded	Student Response		**Percentage (%)**	
1.	How do you feel while taking math lessons?	Senang	Tidak Senang	Senang	Tidak Senang
		20	4	83,33%	16,67%
2.	Do you feel happy or unhappy with the components below	Happy	Not happy	Happy	Not happy
	a. Subject matter	22	2	91,67%	8,33%
	b. Student Worksheet	21	3	87,50%	12,50%
	c. Evaluation of Learning Outcomes	20	4	83,33%	16,67%
	d. Learning Atmosphere in Class	22	2	91,67%	8,33%
	e. How to learn	22	2	91,67%	8,33%
3.	Are the following learning components new or not new to you?	New	Not New	New	Not New
	a. Subject matter	23	1	95,83%	4,17%
	b. Student Worksheet	23	1	95,83%	4,17%
	c. Evaluation of Learning Outcomes	22	2	91,67%	8,33%
	d. Learning Atmosphere in Class	20	4	83,33%	16,67%
	e. How to learn	21	3	87,50%	12,50%
4.	In your opinion, is the language used in the learning components below clear or unclear?	Clear	Not Clear	Clear	Not Clear
	a. Student Worksheet	22	2	91,67%	8,33%
	b. Evaluation of Learning Outcomes	23	1	95,83%	4,17%
5.	In your opinion, is the appearance (writing, illustrations/pictures, and location of pictures) of the following learning components interesting or unattractive?	Attractive	Not Attractive	Attractive	Not Attractive
	a. Student Worksheet	23	1	95,83%	4,17%
	b. Study Results Test	22	2	91,67%	8,33%

The material chosen for the learning device developed is Arithmetic Sequence.The trial results show that the Arithmetic Sequence topic is suitable and very well taught with the PBL model. During the trial, many students actively expressed their opinions, occasionally students asked things they did not understand. Students become enthusiastic in learning because the implementation of learning activities with the PBL model is carried out by involving problems that exist in the surrounding environment, and carrying out group activities makes students more relaxed and lighter in making activity reports. In addition, students also try to think critically in solving the problems given. In other words, the use of PBL can increase students' understanding of what they are learning (Ngalimun, 2014).

Based on the test results, it can be concluded that PBL makes learning more meaningful. Students will remember learning material longer when learning becomes meaningful and useful. In addition, students who learn based on things that are often encountered in everyday life will help them remember learning materials related to this. Students who find learning materials and concepts independently will take longer to remember the concepts they have built. The Ministry of Education and Culture stated the same thing through Abidin (2014) stating that: (1) With the PBL model, meaningful learning will occur.Students who learn to solve a problem will apply the knowledge they have or try to find out the knowledge needed. Learning can be more meaningful and can be expanded when students are faced with situations where concepts are applied; (2) In a PBL model situation, students integrate knowledge and skills simultaneously and apply them in relevant contexts; (3) The PBL model can improve critical thinking skills, foster student initiative in work, internal motivation in learning, and can develop interpersonal relationships in group work.

4. Conclusions and Suggestions

Based on the research objectives and the research process for the development of learning tools, the following results were obtained: (1) The development of Arithmetic Class learning tools with the PBL learning model was developed based on the modified 4-D development procedure through 3 stages, namely the definition stage, the design stage. , and development (develop); (2) The resulting learning tools consist of LIP, SW, and LOE; (3) LIP, SW and THB are appropriate to be used in terms of validity, practicality, and effectiveness. The validity of the learning tools (LIP, SW, and THB) developed were reviewed from the results of the assessment by the validator.The results of LIP development with an average assessment score of 4.44, the results of developing SW with an average assessment score of 4.34 and LOE with an average assessment score of 4.20. The practicality of using mathematics learning tools in terms of observing the teacher's ability to manage learning and filling out student response questionnaires. The results showed that the teacher's ability to manage learning at the first meeting was in very good criteria with an average assessment score of 4.56 and at the second meeting at very good criteria with an average assessment score of 4.78 as well as student responses to the device and implementation. positive learning with categories above 80%. The effectiveness of the use of mathematics learning tools is measured by the percentage of learning mastery and the average value of the evaluation of learning outcomes.Based on the results of the LOE, it is shown that the percentage of learning completeness in Class X State Vocational High School 1 Modoinding is 87.50% and the average LOE score of all students is 77.29. Thus it can be concluded that the lesson plans, SW, and LOE used in learning are effective.

Based on the results and various case findings both during theoretical studies and in the field, it is recommended for further researchers that: (1) The resulting learning tools in the form of lesson plans, SW, and LOE instruments have met the assessment criteria based on aspects of validity, practicality, and effectiveness so that it can be used as an alternative source used by teachers to support learning activities; (2) The mathematics learning tools developed in this research are still limited to the Arithmetic Sequence topic, so it is possible for other researchers to develop mathematics learning tools with other topics. In addition, the learning tools developed in this study can be used as reference material in the development of mathematics learning tools on other topics.

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