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Development of Mathematics Learning Devices Based on Flipped Classroom Strategy to Improve Mathematical Connection Ability of Students From the Tenth Class at SMA/MA

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Abstract: One of the factors that determines the success of learning mathematics is learning students activity. One way to increase students actuvity is providing learning toolsbased on the flipped classroom strategy. These learning tools are expected to increase the activity and maximize the learning process in the classroom, as well as an impact on improving the ability of mathematic students, especially in mathematical connections. The research carried out the development of learning tools in the form of Learning Implementation Plan (RPP), Students Learning Worksheet (LKPD) and Mathematics Learning Video based on flipped classroom strategy. This study was conducted on purpose of designinga valid, practical and effective learning tools based on flipped classroom strategy for students of Senior High School Students At X grade. The development study was using the Plomp development model consisting of three phases. In the initial investigative phase, needs analysis, curriculum analysis, concept analysis and students' analysis are performed. In the Prototype development phase, a formative evaluation was conducted which consists of self-evaluation, one-on-one evaluation, expert review, small group evaluation, and field testing. In the assessment phase, carried out a test for the students of Senior High School Students At X grade to see the learning outcomes in the form of mathematical connections of students after learning by using these learning tools. Based on the development that has been implemented, produced a valid, practical and effective learning tools based on flipped classroom strategy for Senior High School Students At X Grade. It is valid, because it has been in accordance with learning activities with flipped classroom. It is practical, because it can be used on learning for both teachers and students. It is effective, because it can improve the ability of mathematical connections of students who have implemented learning by using these learning tools.

Key Words: *Flipped Classroom, Conection Skill, Plomp Development Model*

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I. INTRODUCTION

Mathematics is something related to numbers, symbols, and formulas and has a definite answer. However, mathematics is also an activity to discover and study patterns and relationships of mathematical concepts. Mastery of mathematics can not be separated from the basic concept. A must thing to do first in mastering the science of mathematics is understanding the concept of mathematics.

Based on Permendiknas No. 22 of 2006, mathematics subjects aims to make learners have ability to understand the concepts of mathematics, explaining the interconnection between concepts and apply the concept or algorithm in a flexible, accurate, efficient and appropriate way in solving the problem [1]. In learning mathematics, there are aspects that influence the level of success in learning process, one of the aspects that influence it is the ability of mathematical connections.

The ability of mathematical connections can be interpreted as the ability to see the relationship between mathematical concepts internally and externally. Internally, that is the concept with mathematics itself, whereas external is mathematics relevance with other study and with daily life [2]. Based on the statement, with the ability of mathematical connections, learners can understand the material being studied better.

Mathematical connections is an essential part of mathematics and mathematics education. Without a good mathematical connection, the development of mathematics will be hampered. Mathematical connections is principal thing in teaching, correcting and learning mathematics [3].

Mathematics learning nowadays requires learners to be able to participate actively in learning. The special purpose of learning mathematics in schools is the realization of the function of mathematics as both a tool, as a mindset as well as a science [4]. The government has made various efforts to make this happen. One of the steps taken is through curriculum improvements. From the 2004 curriculum, KBK, KTSP and now the curriculum of 2013. The 2013 curriculum aims to prepare Indonesian people to have the traits of life as individuals and citizens who are faithful, productive, creative, innovative and effective [5].

Mathematics learning that is implemented in schools today in general still has not given the opportunity to learners to develop their abilities in accordance with the purpose of learning mathematics. Lessons learned, don't support learners to be active. Learning in the classroom, focused on the presentation of material from teachers to learners. The time spent discussing exercise questions tends to be less, so learners are also less able to solve various problems and impact on the weakness of learners' understanding of the material and the low mathematical ability of learners, especially the ability of mathematical connections. Lessons learned during this time tend to use the mathematical package book provided by the government. In addition there are some schools that use other teaching materials such as LKPD, but of course LKPD which is designed must be in line with the expected learning objectives and can improve the ability of mathematical connections of learners.

Based on the problems that have been stated above, it is necessary to develop learning tools mathematics class X SMA/MA that can improve the ability of learners mathematical connections. Therefore, this research has designed learning device based on flipped classroom strategy to improve mathematical connection ability of class X / SMA. This learning is supported by learning videos and LKPD which will help learners in learning. Teachers are required to provide self-designed learning videos as well as using existing videos. Learning videos contain materials that will help learners understand the material before they start the classroom learning. Next, learners discuss in the classroom and work on the questions available in LKPD that have been designed. Through the discussion, students are expected to be more active so they can understand the material and can work on more questions because the time available in the classroom is prioritized for discussion and work on the practice questions. This is in line with Kim et al's opinion in his research that through interaction with video learning outside the classroom, learners feel more confident and better prepared to discuss in the classroom [6] Mc Givney Burelle and Xue also said that learners can pause or watch the video whenever they can, the lessons become effective because learners can give notes about the videos that have been watched [7].

The formulation of the problem in this research is "How is the characteristic of flipped classroom-based mathematics learning device that is valid, practical and effective in improving mathematical connection ability of class X / SMA?" The purpose of this study is to develop a flipped classroom-based mathematical learning device that meets the valid, practical and effective criteria to improve the mathematical connection ability of the X / SMA students. In addition, this study is expected to be useful for teachers and learners as additional learning tools that can be used in learning mathematics in schools. The result of this research is RPP which is designed by applying learning based on flipped classroom and LKPD designed also related to learning video. RPP, LKPD and developed learning videos are limited to compositional function and inverse functions in the odd semester of SMA / MA class.

Flipped classroom develops a way of teaching. The teacher does not have to explain longer in front of the learner and talk for 30-60 minutes [8]. In learning with flipped classroom, learning in the classroom can be used to discuss things that learners find difficult, discussing and working on problems. While outside the classroom, learners can individually or collaborate with their friends to understand the material with the help of other media. Flipped classrooms do not just change classes. Teachers in the world use this model to teach in the classroom at all curricula in elementary through high school [9].

Flipped classroom strategy in conjunction with the technique of learning, consists of two parts, namely the interaction of group learning in the classroom and using computer / tablet / android individually outside the classroom. Learners read the material, watch the learning videos before they come to class and they start discussing, exchanging knowledge, solving problems, with the help of other students and teachers.

Learning Implementation Plan (RPP) is a learning plan developed in detail referring to the syllabus, textbooks, and teacher manuals. While Student Worksheet (LKPD) is one type of teaching materials that help learners in the learning process. LKPD contains steps of activities that must be done by learners to find the concept of learning and exercises [10].

One of the factors that determine the success of learning mathematics is the learning activities of learners. But in fact, it is still often found learners tend to do learning when outside school hours, other than that learners only learn at home when getting the task. In the active learning of learners involved in teaching and learning process, not only teachers convey the knowledge that teachers have to learners, but learners get knowledge with their involvement actively in learning activities.

Activity of learners in following the learning process can be seen through ; (1) desire, courage display interest, needs, problems, (2) desire, courage, and opportunity to participate in preparatory activities, process and continuation of learning, (3) / activity of learning in conducting and completing teaching and learning activities to achieve success, (4) Freedom / freedom to do so without the pressure of teachers / other parties (self-independence) [11].

II. RESEARCH METHODS

This type of research is a development study using the Plomp model, which consists of three phases are preliminary research phase, prototyping phase, and assessment phase. The preliminary research phase consists of needs analysis, curriculum analysis, conceptual analysis and learner analysis. In prototyping phase, making of prototype is done formative evaluation. Phase development or prototype (prototyping phase) consists of prototype 1, named self-evaluation (self evaluation); prototype 2 is one to one; prototype 3 is small group; prototype 4, that is field

test. In the assessment phase, field test is done in MAN XM 2 Mukomuko to see the practicality and effectiveness. Research data was collected through self evaluation sheet, validation sheet, observation sheet and interview guide, teacher and teacher response questionnaire, observation sheet of RPP implementation, sheet and final test of learning result.Validation of learning device conducted by five lecturers consisting of three people lecturer of Mathematics, one lecturer of Indonesian language and one lecturer of Educational Technology.

III. RESULTS AND DISCUSSION

Here is described the results obtained based on research that has been implemented along with the implementation process.

A. Initial Investigation Phase

The preliminary evaluation phase was conducted with the aim of identifying the shape and characteristics of learning tools to be developed. This phase is carried out several activities, among others, needs analysis, curriculum analysis, concept analysis and analysis of learners.

Based on demand analysis, it is found that teachers have used RPP based on curriculum in 2013, but the strategies used are not yet facilitate learners to be active while studying in school. In addition, teachers do not have adequate teaching materials. Along with that, learners are often not ready when studying in the classroom, because students have no source of learning at home, so that learners only depend on explanations from teachers.

Based on the analysis on the curriculum, it is implemented on two aspects, that are Core Competence (KI) and Basic Competence (KD) for class X / SMA. KI and KD refer to the provisions of curriculum 2013, while indicators of achievement of competence, researchers adjust to RPP that researchers develop. The material taken for device development in this research is the material of composition function and inverse function.

In concept analysis, activities are carried out identifying, detailing, and systematically compiling the main materials that will be learned by learners. The material, arranged systematically. The material to be used in this research is material of composition function and inverse function. Lesson learned include: Finding and determining the results of arithmetic operations of functions, Resolving problems involving arithmetic operations on functions, Determining the results of operations of the composition of functions, solving problems involving the operation of the composition of functions, Finding the concept of inverse functions, resolving the daily problems associated with function composition and inverse a function.

Based on the analysis of learners, it can be concluded that learners difficulties in receiving lessons taught by teachers in schools, this is because learners are not ready to learn in the classroom. Based on interviews with learners, learners want a source of learning that is interesting and not boring.

B. Development Phase Prototype

1. Designing Learning Tools

Preliminary Research results serve as a basis for developing or creating prototypes. Once the indicators are formulated, as well as concept maps are set, the next step is to design learning tools in the form of RPP, LKPD and learning videos. The following will describe the characteristics of RPP, LKPD and learning videos based on the flipped classroom strategy that has been designed.

a. Characteristics of RPP

Learning Implementation Plan (RPP) is a guide for teachers in the implementation of learning. RPP is prepared for each KD that can be implemented in one or more meetings. The teacher designs an RPP fragment for each meeting that is tailored to the scheduling in the educational unit.

Learning activities consist of three stages: the introduction, the core and the cover. In the three activities there are steps of defense-based pursuit of flipped classroom strategy. Preliminary activities are the stages to convey learning objectives and motivate the function to generate motivation and focus the attention of learners to be actively participate in the learning process and create a responsive atmosphere of learning. The lesson activities in the lesson plan begin with the teacher presenting the instructional video footage and asking / checking the students, whether they have been watching home learning videos. Then the teacher asks the students to answer questions or questions contained in LKPD with their respective group's friends and discuss the answers.

A good LKPD is LKPD that can be used according to the learner's abilities. The ability of different learners makes it possible to study with a group discussion system. Learning with group systems that are heterogeneous, will make learners with low ability to learn with members of groups who have high ability. It is therefore important to select the right group discussion model so that all group members can play an active role in group discussions. The learning model chosen is cooperative learning.

b. Characteristics of LKPD

LKPD developed according to core competencies, basic competencies, indicators and learning objectives. Presentation of materials at LKPD begins with preliminary activities that are able to express participants' understanding of the material presented in LKPD, besides, the learners are also directed to add matters relating to the

material learned at the time, but not explained in LKPD. The goal is that participants can do more to contribute and be active in learning activities. Learners find their own material and understand it. The role of teacher here is when the teacher guides the discussion, answers the questions of the learners, and provides confirmation or reinforcement of the learners' understanding of the material.

The group discussion activity ends with a group presentation that can represent how the learners understand the material and put in the solution of some sample questions. The teacher manages the course of the discussion to match the set time, which is 45 minutes. After the group discussion is over, learners are asked to answer self-training questions. This problem is given with the aim that learners are able to understand their own potential by answering the problem without help of others. It can also be a benchmark for teachers at every meeting of the learning process takes place.

c. Characteristics of Video Learning

The instructional video contains an explanation of the material and sample questions. This learning video is the work of the researchers themselves. Video learning is made by using sparkol video scribe program. The contents of each video are according to the material on the RPP and the problem to LKPD. The number of instructional videos designed are six videos that will be tested only, namely for material composition function and inverse function. Other learning videos were not created due to limited development time.

The video specifications made are described as follows. Video duration from 15-20 minutes. This is done so that learners do not get tired of listening to the video with a long duration. Type of video is MP4 so it can be watched on computer, tablet and all kind of android type mobile phone. Capacity of each video is approximately 500 MB. Each learning video is designed, duration ± 15 minutes to 20 minutes. Each video consists of opening, content and cover. Opening video is made so that learners know the purpose of learning and get motivated before learning through video. In accordance with the nature of flipped classroom is the material learned learners outside the class then the next video content is the teacher's explanation of learning materials. The focus of the video in this section is writing with the sparkol video scribe program with explanation through the teacher's voice. This is tailored to the learner's request in the previous phase that wants an interesting learning video. In addition, there are also examples of problems to make students more complex understanding of the material that has been listened to. Closing activities are made with the aim of motivating learners after learning through learning videos. The language used in the learning video is communicative language so it is easy to understand by the students of class X high school. For example, in a designed learning video, the teacher utters the phrase "After you finished watching this learning video, did you understand well the composition and inverse function? If not, then please repeat this learning video until you really understand it well. "

2. Prototype 1 and 2

Prototype 1 is an early stage design of learning tools. To obtain a valid device, there are two steps done in validating the learning device, which is self evaluation and expert review.

a**. Results Self Evaluation (Prototype 1)**

This activity is carried out by the researcher himself before being assessed by the experts, with the aim of investigating the errors that occurred in the design of the prototype learning device 1. The self-evaluation is done by re-reading the RPP design, reading and evaluating the LKPD and listening back to the learning video. The self-evaluation of instructional devices is implemented with the aim to see if there are still errors made when creating prototype 1 learning device. Matters to be considered for self-evaluation are typing errors, clarity of writing, image clarity, misuse of terms, misuse of punctuation, LKPD completeness and instructional videos, instrument clarity for RPP validation, LKPD, and learning videos.

After the evaluation itself, some errors found in prototype 1 RPP, LKPD, and learning video. the error is then researcher fix. The error is like, In RPP there are some typing errors, the use of punctuation. In LKPD, There are some typing errors, misuse of punctuation, the columns for filling the problem are too small. In the learning video, there are some videos that are poorly lit, there is less obvious writing in the video due to the lessen the video size of learning.

b. Learning Tool Validation Results By Expert Review

Prototype 1 learning device that has been designed and self-evaluated, is validated. Validation of learning devices is carried out by experts in their respective fields. Before being validated by them, first prototype 1 learning tools that have been evaluated and revised, is consulted to the two supervising researchers. Based on the results of guidance by Counselors I and II, obtained some suggestions for improvement of prototype 1 learning device. The following is a description of the improvement suggestions and the results of the prototype 1 improvement of learning tools based on the suggestion by the two mentors of the researcher. First, improve the learning objectives of the less precise RPP, pay attention to the learning steps in the core activities, adjust to the steps based on the flipped classroom, correct the use of sentences and punctuation. Secondly, in LKPD, correct the sentences used in making the problem, because there are some errors in the use of the question word. Third, note the clarity of sound and writing contained in the learning video.

After conducting guidance and improvement of prototype 1 learning device, the next activity is to validate the product. The validation is carried out by five experts, consisting of 3 mathematics education experts, one language expert, and one educational technologist. The list of validator names can be seen in Appendix 1. The focus of this activity is on the validity of the content and validity of the prototype construct 1 learning device. So in general that is done assessment in terms of content, language and display prototype 1 learning device. Here is a description of the results of RPP validation, LKPD and flipped classroom based mathematics learning videos.

1) RPP validation results

RPP validation is performed by the five validators, during the validation phase some suggestions for improvement of RPP are obtained. The revision made is in accordance with the suggestion of the validator. Advice from validator to prototype 1 RPP that are, (1) Adjust Indicator of Competency Achievement with subject matter, (2) Note the use of sentence according to Indonesian Spelling (EBI), (3) Fix the use of punctuation inappropriately.

After making a revision based on the suggestion of the validator, the results of the improvement are shown back to each validator and are judged quantitatively. Overall the developed RPP is said to be very valid with an average of 3.35. So, it can be concluded that the RPP-based flipped classroom strategy is valid. The results of RPP validation data analysis based on the flipped classroom strategy can be seen in Appendix 12. Prototype 1 RPP which has been valid is then named Prototype 2 RPP.

2) LKPD validation results

To obtain valid LKPD and in accordance with the expected objectives, Prototype 1 LKPD is validated by five experts who will advise and assess the LKPD according to the expertise of each expert or validator. Validator consists of three lecturers of Mathematics Education, one lecturer of Language, and one lecturer of educational technology. Based on consultations conducted on each validator obtained some suggestions for improvement of LKPD. Revisions to LKPD are conducted in accordance with the suggestion of the validator. Suggestion of validator to LKPD is (1) Complete LKPD with answer key, (2) Complete cover design with picture representing material, (3) Note the color composition, font size and picture not yet porposional on LKPD cover, (4) Fix the use unfounded sentences and improper use of punctuation.

After making a revision based on the suggestion of the validator, the results of the improvement are shown back to each validator and are judged quantitatively. Overall the developed LKPD is said to be very valid with an average of 3.35. So, it can be concluded that LKPD based on this flipped classroom strategy has been valid. The result of RPP validation data analysis based on the flipped classroom strategy can be seen in Appendix 14. Prototype 1 LKPD which has been valid then named Prototype 2 LKPD.

3) Video Learning validation results

To get a valid learning video that matches the intended purpose, Prototype 1 learning video is validated by five experts who will advise and rate the learning video according to the expertise of each expert or validator. Validator consists of three lecturers of Mathematics Education, one lecturer Language, and one lecturer of educational technology. Having been asked for suggestions and expert feedback on the learning video, some suggestions and suggestions for revising the learning video were made. The learning video was revised based on the advice of the specialist. The suggestions from the validator for the improvement and revision of the learning video are: (1) Pay attention to the lighting in the video, (2) Fix the introduction / opening section of the learning video, make it more interesting, (3) Fix the text that looks rather blurry in the video, (4) Voice is more emphasized in explaining the material.

After making a revision based on the suggestion of the validator, the results of the improvement are shown back to each validator and are judged quantitatively. Overall learning videos developed are said to be very valid with an average of 3.35. So, it can be concluded that the RPP-based flipped classroom strategy is valid. The result of data analysis of learning video validation based on flipped classroom strategy can be seen in Appendix 18 and 19. Prototype 1 video of valid learning then named Prototype 2 learning video.

c. One to One Evaluation

One-on-one Evaluation Prototype 2 instructional device was conducted at the test school in MAN 2 Mukomuko. The one-on-one evaluation of LKPD consists of three learners with different abilities ; medium, low and high ability. One-on-one evaluations of LKPD are conducted with the aim of identifying possible errors such as grammar that are not understood, unclear instructions, ease of use, attractiveness, and satisfaction. One-on-one evaluation was conducted 6 meetings.

One-on-one evaluation is done by asking learners to understand and do the activities contained in LKPD. Although in LKPD activities should be carried out in groups, but in the evaluation one-on-one learners are required to work individually. During a one-on-one evaluation, the researcher monitors and conveys to the learners the obstacles encountered during the activities in the LKPD at each meeting. These constraints become a record for the researcher for improvement materials. Furthermore, after completion, each learner is interviewed about the LKPD. After improvement on LKPD based on one-on-one evaluation, Prototype 2 learning tools are evaluated by implementing learning in small groups of learners or small group evaluation.

d. Small Group Evaluation

Prototype 2 learning device was tested in small group against 6 students of MAN X class 2 Mukomuko. The purpose of small group evaluation is to identify the lack of learning tools. Small group evaluation is carried out by implementing real learning, only with limited learner.

After the implementation of learning all the meetings are completed, then the researchers conducted interviews with learners to see the practicalities of learning tools. From the results of these interviews, practical learning tools are obtained. Based on interviews conducted, the researcher knows that the average learner with high ability, medium and low able to understand the material presented in the learning video. Learners watch the learning video repeatedly. Learners also feel helped by group discussion. In addition, through discussions and learning videos that have been witnessed the learner also felt able to complete the matter of self-provided exercise.

e. Field Test

Prototype 4 LKPD and the next learning video were tested on a large group that is one class of X / MA high school students. Meanwhile, the prototype 4 RPP is attempted by the Mathematics Teacher of SMA / MA Class X. The test subject of prototype 4 learning device is the students of XA IPA MAN 2 Mukomuko class and the math teacher who teach in that class. While the researcher acts as an observer. Trials were conducted to evaluate the practicality / function of RPP, LKPD and learning videos used in flipped classroom strategy-based learning. The evaluation was conducted in 6 meetings. Before using RPP, the researcher gives explanations to the teacher about the flipped classroom learning steps being undertaken. In addition, the teacher also provides an opportunity for researchers to explain the activities of this study in the trial class.

C. Assessment Phase

The assessment phase is carried out after the learning device is tested at the field test stage conducted on class X MAN 2 Mukomuko students. Assessment is carried out to assess the practicality and effectiveness of learning tools. In the assessment phase, researcher conducted an evaluation of the learning process, which was carried out to look at the harmony of the implementation of the model with the design created [14]. Practicality of learning tools is assessed by providing a questionnaire of practicality to teachers and learners who have implemented learning with these tools. While effectiveness is assessed by giving a test to see the learners' learning outcomes. The aspect of effectiveness observed in this learning is the mathematical connection ability of learners. Students' answers are assessed by scoring rubric of mathematical connection capability. Provision of questionnaires and tests on learners for assessment are carried out after completion of the learning at the field test stage.

1. Practicality of Learning Devices

a**. Practicality of Teacher Learning Devices**

Based on interviews with teachers after the lesson learned on field test activities, the teacher said that the RPP can be run easily. However, if this is implemented it will be difficult for teachers to prepare learning videos. Researchers then said that teachers can also use video learning that has been used by others, teachers can find it on youtube. Based on the interview, the teacher also said that the problems in LKPD are very helpful and in accordance with the KD material to be achieved. The LKPD can be easily used by teachers and learners.

From the observation result obtained the value of RPP practice by the teacher is 87% which is on very practical criteria. From the data obtained, both through questionnaires and observations obtained similar results, namely learning tools, especially RPP has been practical. So it can be concluded that the learning activities in the lesson plan can be implemented well by teachers in learning.

b. LKPD Practices by Learners

Based on the questionnaire filled by the learner after the lesson learned on field test activity, LKPD practice score is 84,4% which is in very practical criteria and the instructional video practice is 82,3% or on practical criteria. Thus, it can be concluded that the learning activities in LKPD have been well implemented by learners and LKPD as well as learning videos can be easily used in learning. In addition, based on the interview also known that overall LKPD based Flipped Classroom is quite practical. It is known that LKPD and instructional videos can help learners to understand learning materials and videos are also easy to use by learners.

c. Effectiveness of Learning Devices

Flipped Classroom mathematics learning tools effectiveness is seen by conducting tests to determine the ability of learners mathematical connections. The instrument used is a matter of essay test. Based on the results of tests that have been carried out by scoring the ability of learners mathematical connections, obtained the average value of learners mathematical communication ability is 88. Based on the test results, it is seen that the value of learners are above the KKM, and the percentage of students who complete exceed 75% means the product can be said to be effective. In addition, when viewed from the first meeting of the classroom product tests, it appears that the number of learners who answered self-training questions correctly increased up to the sixth meeting, and the mistakes of learners in answering questions refer to indicators of mathematical connection capability reduced every meeting . This means that the mathematical connection ability of learners increases.

IV. CONCLUSIONS AND RECOMMENDATIONS

Based on the development process that has been implemented, the results obtained in the form of learning devices based on flipped classroom mathematics strategy for material functions and inverse function of class X SMA / MA semester odd form of valid, practical and effective RPP, LKPD, and video learning.

Based on the research that has been implemented, it can be suggested that the learning device based on flipped classroom mathematics for the material of compositional function and inverse semester function in the form of RPP, LKPD and instructional video developed has valid, practical and effective and can be used in learning mathematics in school and expected to test continued in other schools to see the wider practicability and effectiveness of the developed learning tool.

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