Flipped classroom based mathematics learning equipment for students in grade X SMA

Armiati¹*, Yerizon¹, and Resi Niscaya²

¹Lecturers of Postgraduate Program, FMIPA UNP
²Mathematics Teacher, SMP Kristen Kalam Kudus Padang

*armiati@fmipa.unp.ac.id

Abstract - Learning equipments is a guideline in carrying out a study. In mathematics, a learning equipments should facilitate learners actively construct knowledge and pursue learning conditions that allow learners to practice mathematical ability. Flipped Classroom learning is one lesson that can facilitate active learning because learning is swapped with classroom learning activities outside the classroom with technology. A video learning is one that helps students to learn outside the classroom. Therefore the research conducted with the aim of developing the flipped classroom-based math learning for learners grade X SMA valid, practical and effective to reach math learning goals. The equipments that was developed consisting of Learning Implementation Plan (RPP), Student’s Worksheet (LKPD), and instructional videos. The experiment was conducted using Plomp development model which consists of three phases, namely a preliminary investigation, development phase, and assessment phase. In the phase of preliminary investigations carried out a needs analysis, curriculum analysis, analysis of the concept and analysis of learners. In the development phase conducted its own evaluation, expert review, one to one evaluation, small group evaluation and field test. In the assessment phase achievement test conducted to see the effectiveness of the equipments developed. Instruments used to collect data in this study is guideline interviews, questionnaires, observation sheets and achievement test. Data obtained were processed descriptively and quantitatively. Subject test in this study was the students of grade X SMA Negeri 6 Padang.

1. Introduction

Learning is a condition that is deliberately created by teachers to make students learn. An appropriate strategy to be used is by creating an active learning. Active learning means students not only become the object of learning, but also become the subject of learning. When students become the subject of learning, students are cognitively active to process knowledge in achieving a holistic understanding of what they learned. In order for students to be cognitively active, Thorndike's learning theory[1] stated that students should prepare themselves before taking lessons (Law of Readiness). So students should learn at home before actively discussing and solving mathematical problems at school.

The aforementioned learning is known as Flipped classroom which is a learning that seeks to utilize the exchange of learning situations aimed of making learning in schools more effective, so that active learning can be carried out. According to Johnson, Graham Brent [2] flipped classroom is a learning model that minimizes the number of direct instructions in teaching practice but maximizes student to student instructions.
Lage et al [3] explained that flipped classroom as a condition where things usually done in a classroom can be done outside the classroom, and vice versa. This strategy utilizes technology that provides additional learning materials for students which can be accessed online or offline everywhere at any time. This means, flipped classroom facilitates students to prepare themselves by learning before entering the class, so that in classroom learning, students can use time to collaborate with friends to practice skills or make feedback from learning obtained from outside the classroom.

Bregman & Sams [4] explained that through the implementation of flipped classroom learning, students (are forced to) have time to study subject matter at home, thus they will be more independent and not just waiting for information from the teacher. When studying at home, through instructional videos, students can create their comfortable conditions to learn according to their ability in receiving the learning material.

By using flipped learning based learning videos, the classroom learning can be more effective, teachers do not need to repeat the presentation of learning materials in many other classes, but they can use the prepared media. By doing this, the time used in the classroom can be saved, because the teacher does not need to present all the materials in the class, except certain difficult parts that have not been understand by the students. This can be the solution of the teachers’ difficulty in general who often lose time because of the frequent repetition of the material in the classroom due to students who have not prepared to study at home first. In addition, it can motivate teachers to improve their ability in using technology to support the learning[4].

Based on Unruh’s findings [5], it is known that teachers who use technology in flip classes have greater comfort in teaching. Moreover, students also have a greater level of involvement because they give positive attitude to the technology used. This show that teacher and students will be more motivated in conducting flipped classroom when the technology is utilized.

Some results of related researches such as the study of Afrilyanti, et al (2016) [6], Aditya [7], McLauhin et al (2016) [8], Rebecca et al (2015) [9] concluded that students who learned through flipped classroom get a lot of advantages in learning, learning is more effective and enjoyable.

Damayanti [10] suggested that in carrying out flipped classroom learning, teacher must first prepare the learning equipments, one of which is teaching material. Teaching materials are used to support learning and make it easier to understand video content. Students can see flipped classroom videos at home and use the teaching materials to do a resume or to try out their understanding directly after watching to the provided video. The teaching materials also play role to equalize students’ perceptions in the class since the students can show the results of their understanding of the video they have watched.

Bregman & Sams [4] states that flipped classroom can be applied to various subjects and various materials, including mathematics. The application of flipped classroom in mathematics classes will be very beneficial for teachers and students.

Learning is created through designing learning equipments by the teachers. Learning equipments are materials, tools, and media used during the learning activities and are used to achieve expected learning goals. Learning tools can be in the form of learning implementation plans, syllabus, and teaching materials. Learning tools designed are one of key factors which determine successful learning.

According to information from several senior high school mathematics teachers in Padang (August 2016), it is known that in general teachers have designed learning equipments which aimed to active learning, however the learning outcomes obtained by students are not maximal. During the class, mostly the learning is focused in practicing conceptual understanding. According to the teacher, the classroom time allocation is not sufficient to train various other mathematical abilities. In addition, it is also known that students are generally unready to take part in classroom learning. Learners simply rely studying with a teacher without repeating the materials at home before studying at the school. As a result, too much time is consumed in establishing the concept and only a few time left for exercises.

According to the information of the students it is know that they do not learn at home as yet have a teaching material according to curriculum implemented in schools. One of their difficulties at home is the lack of appropriate teaching materials to help students to learn math at home. So students need teaching materials that can always help students learn as well as teachers who help in class. The teacher
also explained that teachers have been trying to create teaching materials in the form of Worksheet but not for each meeting. This is due to the limited time available.

Based on the above concluded that learners are not ready to receive lessons in school. This is because students do not study at home. As a result, they lack the time to practice math in school and learning outcomes to be low. They also do not want to learn at home, because of the unavailability of adequate teaching materials. Therefore, they are not ready to accept the lesson with the maximum at school.

Because the learning equipment is one of the factors that determine the implementation of learning, it is required a learning equipment that can overcome the problems faced by teachers. It is necessary to develop a learning equipment that implements a learning model used in achieving objectives with better mathematics learning. One that can be applied is flipped classroom-based learning model. The learning takes advantage of a technology, such as instructional videos aimed at helping students to learn outside the classroom. Instructional videos are videos containing teacher's explanation of the subject matter or contain the teacher's explanation of the discussion on solving problems related to classroom learning. Through the flipped classroom, communication between teachers and students not only in the classroom but has started outside the classroom which is by providing an opportunity for students to learn the material through a video provided by the teacher.

According to DeVito [11] the communication worksthrough individual who transmit, distribute, and receive distorted in a context, have some effect and to provide opportunities for feedback. The main factors were emphasized in explaining communication is the sender, receiver, distortion and feedback. This gives rise to two-way interactive communication. Therefore, teachers should be using instructional video before learning begins and then ask for feedback from the students in the class, as this may lead to a two-way interactive communication between teachers and the students.

Implementation flipped classroom learning will make the teachers do not lose much time in class to explain the material but merely repeat or emphasize and explain the most difficult part of the material [5]. Students will be assisted by the teacher in a longer period of time compared to conventional learning models. They will also have more opportunities for group discussions, exchange ideas with classmates. Furthermore, to study at home or outside the classroom, students can repeat back through the video material that has been given. The video creates interactive communication between teachers and students.

In addition to utilizing instructional video as a source of learners outside the classroom, teachers also need to develop a resource that can facilitate learning activities in the classroom. It can be in the form of students' worksheet or commonly known in Bahasa Indonesia as Lembar Kerja Peserta Didik (LKPD). LKPD is a teaching material that contains material and questions developed by the teacher to help the learning process in the classroom. The problems in LKPD are directed at students' mathematical abilities. Additionally, LKPD can be used as a means to realize the written feedback of the students about the instructional videos.

Based on the description above, a flipped classroom based mathematical learning equipments was developed. The developed equipments was in the form of flipped classroom based Lesson implementation Plans, Instructional videos and LKPD which became teaching materials during the implementation of learning on Trigonometry in grade X SMA.

2. Research Method
The type of research used in this study is Design Research and uses the Plomp research model. The Plomp model consists of three stages, namely the initial investigation phase (Preliminary Research), the development phase or prototype making, and the assessment phase [7].

The activities carried out at the initial investigation stage were gathering information on learning problems that occur in the field and formulating rational thinking about the importance of developing learning equipment. The next step was working on the theory that underlies the development of the equipment. It is also conducted an analysis of the ability and willingness of learners, learning needs, curriculum, and analysis of mathematical concepts.
In Development or Prototyping Phase, the activities carried out were designing and developing prototypes in this case is in the form of flipped classroom based-mathematical learning equipment. Then a formative evaluation of the devices that have been developed was carried out. Formative evaluation has 4 stages, namely Self-Evaluation, expert review and one to one evaluation, small group evaluation, and field test evaluation. Based on the results of the evaluation, a revision of the prototype was carried out at each phase. Thus, at the end, we obtained a prototype which is valid, practical, and effective to use.

The last phase in the Plomp model is the assessment phase which was carried out by conducting semi-summative evaluation. In this phase the process and learning outcomes of students in using the developed prototype was assessed.

Data obtained in the initial investigation activities were analyzed using descriptive techniques consisting of three stages of analysis, namely reducing data, presenting data and drawing conclusions.

Data validity was processed using the following formula.

\[ R = \sum_{i=1}^{m} \sum_{j=1}^{n} V_{ij} \]  

with \( R \) = average assessment results from experts, \( V_{ij} \) = score of the results of assessment from the expert/practitioner \( j \) of the criteria \( i \), \( N \) = the number of experts/practitioners involves in the assessment, \( M \) = the number of the criteria. Learning equipments considered valid if the average gained more than 2.40.

Practicality of the equipment was processed using the formula by Purwanto [8] as follows.

\[ P = \frac{R}{SM} \times 100\% \]  

with \( P \) = practicality value, \( R \) = gained score, dan \( SM \) = maximum score. Learning equipment are said to be practical if the achievement target of practical values is equal to or more than 75%. The effectiveness test was conducted by looking at the classical result of mathematics test of the students who apply flipped classroom based learning. Flipped classroom-based learning equipments are said to be effective if the test results of students who carry out learning based on flipped classroom show that 75% of students achieve the KKM complete score of 75.

Calculation of learning outcomes is

\[ N = \frac{S}{I} \times 100 \]  

with \( N \) = students’ score, \( S \) = the total score of the students, and \( I \) = ideal score.

3. Results and Discussion

3.1. Results of the initial investigation

The study begins with a preliminary analysis consisting of needs analysis, curriculum analysis, concept analysis, analysis of student characteristics, and literature review. This activity was carried out by interviewing teachers and students, documenting and analyzing the curriculum as well as mathematics books for the grade X SMA, and distributing questionnaires to students. Data obtained in this preliminary analysis is used as the basis for designing learning equipments in the form of learning implementation plans (RPP), instructional videos, and student worksheets (LKPD) based on flipped classroom.

Based on the needs analysis, it is known that the characteristics of the LKPD expected by students are the existence of diverse practice questions with attractive appearance. Because so far, the students only use teaching materials in the form of practice questions provided by the teacher because there is no appropriate supporting book. It is also known that students expect instructional videos with a display that focuses on the teacher’s explanation and the examples of questions that are relevant to the material being taught.

Based on the results of the analysis of the curriculum listed in Minister of Education and Culture No. 24 of 2016, it is known that the expected competencies in trigonometry topic at grade X are trigonometric...
comparisons of right triangles, angular trigonometric comparisons in various quadrants, sine rules and cosine rules, and trigonometric functions.

Based on the analysis of the characteristics of students it is known that students generally like to discuss with friends while working on practice questions. It is also known that grade X students already have good abstraction and are at a high cognitive level.

Based on the analysis of the concept it is known that the first material taught is about the size of the angle and continued with trigonometric comparisons on right triangles. After that, the material was taught about the comparison of angular trigonometry in various quadrants, angles of more than 1 rotation and negative angles. The next material is about the rules of sines and cosines and their application to the area of a triangle. Additional material that needs to be taught is the trigonometric identity and trigonometric equations. This is a fundamental material in trigonometry and is needed to understand the next material, namely trigonometric functions.

The trigonometric function material taught is limited to the simple form of sine and cosine functions and their quadratic form. The tangent, cotangent, cosecant and secant functions are only introduced to students and are not studied in depth.

3.2. Results of the development phase

3.2.1 The result of the design of mathematical learning equipments based on flipped classroom. Learning that is designed is a mathematical learning equipments that implements a flipped classroom model, on Trigonometry material in grade X SMA which is for 1 semester. The learning equipments are for 28 learning activities. However, due to time constraints and the ability of researchers, trial activities were limited to KD 3.9 and instructional videos were developed only for 6 learning activities. Details of material distribution and time allocation can be seen in Table 1.

Table 1. Details of Learning Time Allocation of Grade X SMA for Trigonometry Topic

| KD  | Material                                  | Meeting | Number of week |
|-----|-------------------------------------------|---------|----------------|
| 3.7 | Angle size                                | 1       | 2              |
|     | Trigonometry in right triangles           | 2, 3, 4 |                |
| 3.8 | Special angle trigonometry                | 5, 6, 7 | 7              |
|     | Related angle trigonometry                | 8, 9, 10, 11, 12 |         |
|     | Trigonometric Equations                   | 13, 14, 15 |             |
|     | Trigonometric identity                    | 16, 17, 18 |             |
| 3.9 | Rules of sine and cosine                  | 19, 20, 21 | 3              |
|     | Area of a triangle                        | 22, 23, 24 |               |
| 3.10| Trigonometric function                    | 25, 26, 27, 28 | 2           |
|     | Examination for each KD (4 meetings)      | 2       |               |
|     | Total                                     | 16      |               |
3.2.1.1 The draft of Lesson Implementation Plan (RPP). The RPP component designed was school identity, subject identity, class / semester, subject matter, time allocation, learning objectives, basic competencies and indicators of competencies achievement, learning materials, learning methods, learning media, learning resources, learning steps and learning outcomes assessment.

The preliminary activity in the RPP was the teacher checks the readiness of students whether they have watched the instructional video or not. The teacher follows up by giving reinforcement if students have not watched the video.

The core learning activities begin with the teacher and students discuss about the material display in the instructional video to equate perceptions about the concept and the teacher emphasizes important concepts that need to be understood by students. The next activity is the students do the problems in group discussions. This is based on the characteristics of students who like to discuss with their friends and the demands of learning mathematics that activates students in the classroom. The next activity is the students work on the exercises independently.

The closing activity, as in general, is that students conclude the concept that has been understood and the teacher closes the learning.

3.2.1.2 The draft of instructional video. The designed instructional videos have characteristics that are videos containing teacher explanations about the material and sample of the problems. The video display is focused on the teacher's writing that explains the material with an explanation through the teacher's voice. The duration of each designed video is 15-20 minutes with a capacity of approximately 500 MB. The material and sample questions in the learning video were adjusted to the material in the LKPD and sorted from easy to a more difficult one.

The developed Videos (6 instructional videos) were limited to Sine Rule and Cosine Rule. Each learning video consists of 3 parts, namely the opening, core, and closing parts.

In the opening part of learning in the video contains the giving of motivation by the teacher. The video display in this section is the teacher explain orally the subject matter and its benefits, accompanied by providing motivation to students.

| Cuplikan Video | Keterangan | Durasi |
|----------------|------------|--------|
| Pembukaan Pembelajaran: motivasi dan penjelasan mengenai materi yang akan dibahas dalam video pembelajaran | 20 detik |

**Figure 1.** Footage opening part of the instructional Video

The second part of the video is the part of Learning Content. The video display in this section was the teacher's written when explaining the material along with an oral explanation. The teacher explains the material on a whiteboard like she explains in classroom. After explaining the material, the teacher also gave several sample questions and discussed the solution. Here is an instructional video footage on Learning Content section.

**Figure 2.** Video footage of Content Section: Teachers Explain Materials orally
3.2.1.3 The draft of LKPD. The component of designed LKPD consists of the LKPD cover, introduction, instructions, table of contents, and contents of the LKPD. The contents of the designed LKPD consisted of 4 pieces. LKPD 1 about Comparison of Trigonometry in right-angled Triangle consists of 4 meetings. LKPD 2 about special-angled trigonometry comparison consists of 14 meetings. LKPD 3 on Sinus Rules and Cosinus Rules consists of 6 meetings. LKPD 4 concerning Trigonometry Function consists of 4 meetings.

The LKPD was designed with two core components, which were questions for discussion and questions for exercises. Discussion questions were designed because this is in accordance with the flipped classroom's pillar, which is a change in learning culture that requires student-centered learning. Exercises questions were designed because students need to test their understanding after carrying out discussions.
3.2.1.4 **Self evaluation.** An evaluation was carried out relating to the appearance and validity of the prototype 1 of the designed learning equipments. Based on the results of the evaluation, several improvements were found to the RPP, namely typographical errors and unclear / difficult to understand sentences. In the evaluation of the LKPD, it was found several questions that experienced typographical errors, errors in the use of sentences, and questions that were not in accordance with the learning objectives. The results of the improvement at this stage were called prototype 2 of the learning equipments.

3.2.1.5 **Expert review.** Expert evaluation was carried out in order to obtain data about the validity of the learning equipments. Prototype 2 was validated by 3 mathematical education experts, 1 education technology expert and 1 Indonesian language expert. Based on the results of RPP evaluation, improvements were made to indicators of competencies achievement, improvement of sentences, and improvement of learning objectives. The validity assessment of lesson implementation plans (RPP) was 3.78 with very valid criteria.
Improvements to the learning videos carried out at this stage were related to the appearance of the video and the addition of motivation in the form of contextual problems at the opening part. The value of learning video validity is 3.51 with very valid criteria.

Improvement of LKPD at this stage was related to the display of the LKPD cover and the addition of contextual images. The average value of LKPD validity is 3.40 with valid criteria. Learning devices that have been improved and have valid criteria are called prototype 3 of the learning equipments.

3.2.1.6 One to one evaluation. One-on-one evaluation activities were conducted on 3 students who had different abilities, namely high, medium and low. Students try to use learning videos and LKPD and then provide assessments related to the practicality of videos and LKPD with the previous described aspect. In addition, an assessment of RPP was also conducted by asking for feedback from a mathematics teacher regarding the ease of using the RPP. Based on the results of the one-on-one evaluation, improvements were made to the clarity of the sentence, image, and appearance of the LKPD. While the RPP and LKPD did not experience improvement at this stage.

3.2.1.7 Small group evaluation. This activity was carried out on 6 students with heterogeneous cognitive abilities. In its implementation, students take part in learning activities where the researcher acts as the teacher. Based on this activity, information was obtained about the use level of the learning equipments and their implications for the students’ ability.

Based on the learning activities in this small class, there was no revision of the instructional video because the students stated that they could understand the contents of the video. Moreover, instructional videos have also helped students learn at home. Improvements were made to LKPD 22 in the Notes section, because students were not able to do it well.

Furthermore, the time allocation in the lesson implementation plan is also improved, namely in the preliminary activities it was add 5 minutes to become 15 minutes. This because the preliminary activities require more time to discuss homework and discuss the contents of the instructional videos. This revised flipped classroom mathematics learning equipments is then named Prototype 4 of the learning equipments.

3.2.1.8 Large group evaluation (field test). This activity was to try out the prototype 4 to a class of students in grade X. The instructional videos and LKPD were tested to the students while a mathematics teacher evaluate the RPP. This activity took place in 6 meetings and obtained results in the form of practicality of the developed learning equipments.

The suggestion given by the teacher regards to the learning activities was to vary the cooperative learning model that is applied. This aimed to avoid students in getting bored while studying with the frequently use of the same learning model. Furthermore, some learning videos also need to be given additional questions and emphasis on important things. The teacher also expects learning videos with a louder voice.

Regarding the LKPD, the teacher feels quite satisfied with it because it already has various forms of questions and levels of difficulty. However, there are disadvantages of flipped classroom activities that were applied. According to the teacher, if the teacher lacks control of the students, the students will not watch the instructional videos and flipped classroom will not be effective, because the students' knowledge is not in a same level. So it is very important to remind and motivate students to watch the videos.

In addition, video variations are also needed to make it more interesting. Then the teacher should ensure that students need to watch the videos carefully first before filling in the LKPD.

Based on observation results at each meeting, it is known that each activity observed has been carried out by the teacher. Thus, it can be concluded that Mathematical RPP based on flipped classroom has a very practical level of implementation.

In this activity, information about the practicality of the LKPD was also collected and the instructional videos were tried out to large group students. A summary of students' responses on
questionnaire is given in Table 2 and Table 3. Based on the results of the questionnaire it is known that the learning videos and LKPD developed are practical.

Table 2. Questionnaire Data Analysis Result on Practicality of Instructional Videos.

| No | Rated Aspect                           | Average practical value | Category     |
|----|----------------------------------------|-------------------------|--------------|
| 1  | Readability and clarity of writing, pictures, instructions | 87.5%                   | Very practical |
| 2  | Usability / ease of use                | 82.75%                  | Practical    |
| 3  | Adequacy of time                       | 77.25%                  | Practical    |

Table 3. Questionnaire Practical Data Analysis Results of LKPD

| No | Rated Aspect                           | Average practical value | Category     |
|----|----------------------------------------|-------------------------|--------------|
| 1  | Readability and clarity of writing, pictures, instructions | 80.80%                  | Practical    |
| 2  | Usability / ease of use                | 92.44%                  | Very practical |
| 3  | Adequacy of time                       | 93.75%                  | Very practical |

3.3. The results of the assessment phase on mathematics learning equipments based on flipped classroom

In this phase, the developed flipped classroom based learning equipments were investigated regarding its effectiveness. This was done by giving a test to students who have tried the learning device, namely the subject in the Field Test class.

Based on the results of the test, it was found that 25 out of 32 students had achieved a score of more than 75. This means that 78.125% of students had passed the minimum completeness criteria. Hence, it can be concluded that the flipped classroom based learning equipments that was developed has been effective in improving student learning outcomes.

4. Conclusion and Recommendation

Based on the results of data analysis that has been done it can be concluded that the developed mathematics learning equipments flipped classroom based have been valid, practical, and effective to use in improving student learning outcomes with the following characteristics.

1. Learning equipments have been valid in terms of conformity with the principles of classroom flipped classroom learning, in accordance with the principles of the development of RPP and teaching materials in Permendikbud number 22 of 2016. It has facilitated the achievement of basic
competencies stipulated in Permendikbud number 24 of 2016, paying attention to the characteristics of students’ thinking, abstraction power and learning tendency of students.

2. Learning equipments have been practical in terms of readability, clarity of writing, images, and instructions, easy to use and have a suitable timeline while applying flipped classroom.

3. Learning equipments have been effective because students’ learning outcomes show that more than 75% of students at the time of the trial obtained scores above the standards set by the school, namely 75.

Based on the conclusions above, the mathematics learning equipments based on flipped classroom produced can be used as a guide for teachers in carrying out learning to achieve the expected learning goals.

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