

THE DEVELOPMENT OF SCIENTIFIC APPROACH BASED STUDENTS' WORKSHEET ON TRIGONOMETRY FOR GRADE X STUDENT

Sri Novia Martin^{1*}, Irwan², Sri Elniati³, Dadang Djuandi⁴

¹Master Degree, Universitas Pendidikan Indonesia, INDONESIA, srinoviam@student.upi.edu

²Dr, Universitas Negeri Padang, INDONESIA, irwan.math.165@gmail.com

³MA, Universitas Negeri Padang, INDONESIA, srielniati@gmail.com

⁴Dr.M.Si, Universitas Pendidikan Indonesia, INDONESIA, dadang.djuandi@upi.edu

*Corresponding author

Abstract

Indonesian schools apply the 2013 curriculum in learning, including mathematics learning. The 2013 curriculum emphasizes the implementation of a scientific approach in learning. This research was conducted to develop a teaching material that could support the implementation of scientific approach in learning mathematics. The teaching material developed was scientific approach based student's worksheet. The worksheet displayed material of learning with steps of scientific approach. There are five steps of scientific approach, those are observing, questioning, asking, associating and communicate. The worksheet can be used when it has three characteristics. Those are valid, practical and effective. Therefore in this research, it has to see the three of the characteristics. To develop the valid, practical and effectiveness worksheet, it was conducted a study of research and development (R&D) by using a design model of McKenney. McKenney model consists of three stages. Those were preliminary stage, prototyping stage and assessment stage. This study was conducted in grade X students. Data was obtained from observation, interview and questionnaire. The results revealed that the worksheet was valid, practical and effective. The worksheet can be used in studying mathematic. It can also be a sample for teachers to design a worksheet and help the teachers to know how to design a worksheet.

Keywords: Scientific approach, worksheet, scientific approach based students' worksheet.

1 INTRODUCTION

The purpose of Indonesian education is to educate the nation's life in accordance with the opening of the 1945 Constitution. One of the tools that can be used to achieve that goal is mathematics. In order to achieve the goals of national education, the Indonesian government try to make a renewal education, one of which is the curriculum changes from Kurikulum Tingkat Satuan Pendidikan (Educational Unit Curriculum) to 2013

Curriculum. The 2013 curriculum emphasizes that student learning outcomes are not only judged from knowledge alone, but also attitudes and skills. That is, students are expected not only to master the subject matter but also able to develop their attitude and skills.

The 2013 curriculum emphasizes learning with a scientific approach. The scientific approach is characterized by the projection of the dimensions of observation, reasoning, invention and validation and the explanation of a truth in which the learning process must be carried out guided by scientific values, principles or criteria. The scientific approach includes the 5M steps of observing, asking, trying, associating and communicating (Depdikbud, 2013,p.10).The activity of observing, students are given a fact/phenomenon that is concrete, simple and related to the concepts learned, then students are asked to observe the facts/phenomena given. The process of observing facts/phenomena includes seeking information, seeing, reading or listening. Observation activities conducted in order to attend curiosity and interest of students to the material to be studied. The activity of questioning is done as one of the process of building student knowledge in the form of concept, principle, procedure, law and theory. The goal is that students have high-level, critical, logical and systematic skills. Questioning activities can be done in groups and class discussions. Working in groups provides an opportunity for students to be able to share their ideas. The activity of trying is to improve the understanding of concepts, principles or procedures. The activities try to facilitate students to find their own concepts, principles or procedures so that students do not just memorize but understand the concept well. These activities include planning, designing and carrying out experiments, as well as obtaining, presenting and processing data. The activity of communicating is a means of conveying conceptualization results in oral, written, drawing / sketching, diagrams or graphs. The activity aims to enable students to communicate their knowledge, skills and application, and student creation through presentation, reporting, and/or performance.

The learning process can take place well if supported with the right learning materials. Meanwhile, the scientific approach is new to be applied so that not many teaching materials are available at school or on the market. Textbooks available are still less, especially in the subject of math for interest group (Kelompok Peminatan) in high school level.

Student worksheet is sheets containing a set of activities that must be done to maximize the understanding in the effort to form basic skills according to indicators of achievement of learning outcomes that must be pursued (Trianto, 2010, p.111). The worksheet should not only contain material and questions, but also include activities that students should do and lead them to understand a concept. The Worksheet can assist students in understanding the concept with scientific approach steps. It contains important concepts based on core competencies and basic competencies that must be mastered by students. The colour, background and format of the worksheet writing are tailored to the student's condition and pleasure. The student worksheet developed can make it easier for students to understand the subject matter especially the difficult material. One of the materials that students are difficult to understand and they tend to memorize the formula is trigonometric material. Trigonometry is one of the subjects studied in grade X in the second semester. The sub-materials are trigonometric equations, trigonometric identification and trigonometric applications in life. The preparation of the worksheet should pay attention to some elements. The worksheet consists of six main elements namely title, instruction manual, basic competence or subject matter, supporting information, task and assessment (Prastowo, 2011, p.205). Other elements may be added into it on the basis of need.

The student worksheet developed must contain three characteristics that are valid, practical and effective (Akker, 1999,p.93) Therefore, the developed product needs to be tested for validity, practicality and effectiveness. Validity can be interpreted with the accuracy, truth or validity of an instrument (Sudijono. 206,p.93). The teaching material is said to be valid if it meets the aspect of the validity. The assessment aspects of the validity of teaching materials include the components of content, language, presentation and graphic. The practicality of teaching materials refers to the ease of use of materials. According to Depdiknas (2008,p.28), a practical way are 1) easy and pleased using it, 2) suitable to students because the implementation is easy. While the practical considerations according to him are: 1) ease of use, among others: easy to manage, stored, and can be used anytime, 2) the time required to be short, fast and precise , 3) the appeal of the device to the student's interests, 4) easily interpreted by expert teachers and other teachers 5) can be used as a substitute or variation of other teaching materials.Effectiveness comes from the word 'effective'. According to Badudu and Sutan (1994,p.199), effective means 1) have an effect 2) give satisfactory results, 3) utilize time and manner very well. The worksheet effectiveness can be seen from the influence of the worksheet to students after students learn by using it. If the worksheet has been valid, practical and effective, then the worksheet has been good and qualified. It meant the worksheet can be used in learning mathematics.

2 RESEARCH METHODS

2.1 Design Research

The method of this study was research and development (R & D) with development design model adapted from McKenney model. The development process of the worksheet consisted of 3 stages: preliminary, prototyping, and assessment.

The preliminary stage consisted of content structure, concept and student analysis. Content structure analysis was an analysis of curriculum content that included analysis of core competencies, basic competencies and indicators that students must achieve. Curriculum analysis was done so that the worksheet in accordance with the demands of competence that had to be achieved by students. Concept analysis was conducted by identifying the main concepts of mathematics and organizing them systematically according to the order of presentation. Student analysis includes analysis of age, predilection of colour and image, academic ability, psychomotor and maturity level. The analysis was done so that it was suitable to the students.

Prototyping stage was the stage for designing the worksheet based on scientific approach. Prototyping stage consists of prototype 1, prototype 2 and prototype 3. The Student worksheet that had been designed was called prototype 1. In prototype 1, it was conducted self-evaluation and expert review to test the validity of the worksheet. Self evaluation was to evaluate the prototype 1. Expert reviews were asking relevant experts/experts to provide assessment and input to the prototype that has been designed. After a revision of prototype 1, Prototype 2 was obtained. In prototype, 2 One-to-One Evaluation was performed. One-to-one evaluation is done by asking three students to comment on the worksheet. After one-to-one evaluation, it is revised. Then, do field test. Last is the assessment stage. Assessment stage is conducted to test the effectiveness of the produced worksheet. The effectiveness based on the scientific approach is seen from the result of the student's final test after learning by using the worksheet.

2.2 Research Subject

The subjects of the trial in the development of scientific approach based students' worksheet were the students of Grade X SMA (Senior High School) Negeri 7 Padang. The students were selected as subjects because they had higher intelligence levels and were active in learning compared to other classes so that the students' worksheet were suitable to be tested in this class.

2.3 Research Instrument and Data Analysis Technique

Data were obtained from documents, observations, interviews, questionnaires and a test of learning outcomes. The questionnaires that was used in this were Likert-scale questionnaire adapted from Sukardi (2008) with four alternative answers were: strongly agree (score 5), agree (score 4), disagree (score 2), strongly disagree (score 1). Alternative hesitant answers (score 3) are omitted to avoid the tendency of the student to choose such a hesitant answer. There were two kinds of questionnaire, questionnaire for validity and other for practicality of the worksheet.

Data obtained from documents, observation and interview were qualitative data. According to Miles and Huberman in Sugiono (2012) there are 3 stages performed to analyze qualitative data were data reduction, display data (presentation data), and verification (drawing conclusions). Data reduction is selecting important data and removing unnecessary data. Display data (presentation of data) that presents data documents, observations, and interviews in the form of a brief description. Verification (drawing conclusions) is to make a conclusion about the analysis results of document, observation and interviews.

The data obtained from questionnaire of validity was analyzed by means:

(1) Scoring for each statement of the questionnaire,

(2) Calculating the validity value with the following formula:

$$\text{Value of validity (VV)} = (\text{Score obtained})/(\text{Maximum score}) \times 100\%$$

(3) Determining the criteria of the worksheet validity adapted from Riduwan (2010) .

The questionnaire of practicality was analyzed by means:

(1) Scoring for each statement

(2) Calculating the value of practicality with the following formula:

Value of Practicality (VP) = (Score obtained) / (Maximum score) × 100%

(3) Determining the criteria of the worksheet practicability adapted from Riduwan (2010)

The test of learning outcomes is analyzed by determining the number of students who were pass the test and not. The student would pass the test if their scores reaches KKM (Minimum Criteria of Completeness) determined by the school. KKM subjects of mathematics groups of interest for grade X SMAN 7 Padang is 75. Percentage mastery learning was classically calculated using the following formula:

Classical completeness = (total number of completed students) / (total number of students) × 100%

According to Debdikbud (2013) classical completeness is achieved if the number of students who complete the KKM at least 75%.

3 RESULT AND DISCUSSION

3.1 Description of Preliminary Stage Result (Needs Analysis)

The preliminary stage aims to define the requirements needed to develop the scientific approach based student's worksheet .There were three analysis, those are student needs, content structure and concept analysis.

Analysis of student needs was to see what kind of the worksheet that students need. The analysis was done by doing observation in the learning process and interviews with students and teachers. The observations were conducted in class X.IA2 SMAN 7 Padang during the mathematics learning. Based on the results of observations and interviews was obtained information that students needed a material learning that supports scientific approach implementation.

Content structure analysis was an analysis of the content of the curriculum. Content structure analysis was focused on the Core Competencies and Basic Competencies found in the syllabus. Core Competencies and Basic Competencies to be analysed in this study were about trigonometry with sub-section Trigonometry Equation, Trigonometric Identity and Trigonometry Application.

3.2 Prototyping Stage Results

Prototyping stage was the design stage of the worksheet based on scientific approach. There are three traits that need to be considered in the worksheet design those were content, interface and support (language and legibility). The prototyping stage consists of three steps.

3.1.1 Prototype 1

Here were the results of the worksheet on prototype 1.

1) Content

The worksheet displayed the material of mathematics conducted by scientific approach steps. Each steps are as follows.

a) Observing

The worksheet presented various graphs of trigonometric functions. Activities of suffering could increase the curiosity and interest of students to the material. One example graph of the trigonometric function presented in the worksheet can be seen in Fig 1.

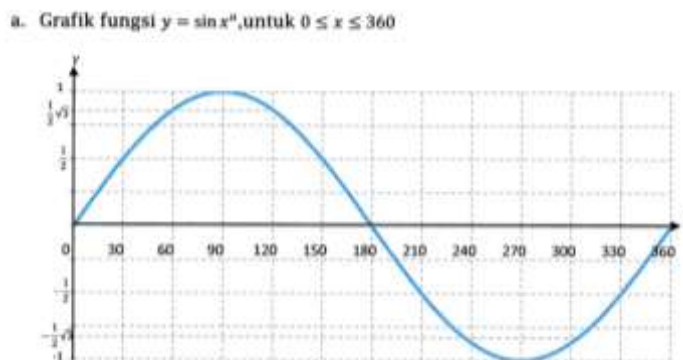


Figure 1 A part of the worksheet for Observing Activities

b) Questioning

Questioning activities were expected to be undertaken by students. After students observed the graph of the trigonometric function, students were given the opportunity to ask questions. Questioning activity was one of the process of building knowledge. The activity asked students to think. If no student asked, then the teacher could lure students with questions. Then the student will recorded the question in the provided column. The columns for the questioning activities that existed in the worksheet can be seen in Figure 2.

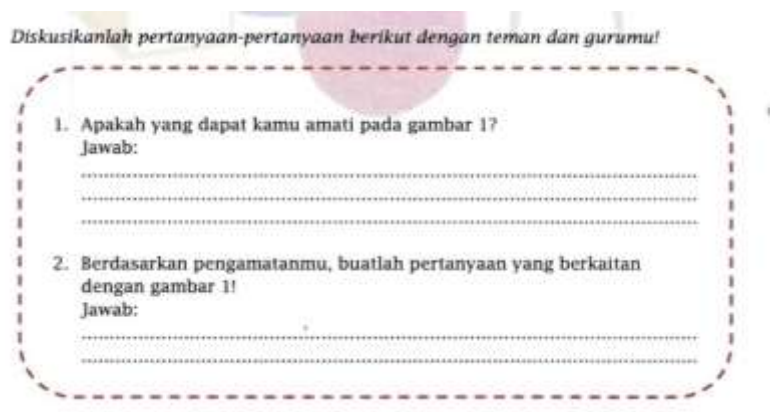
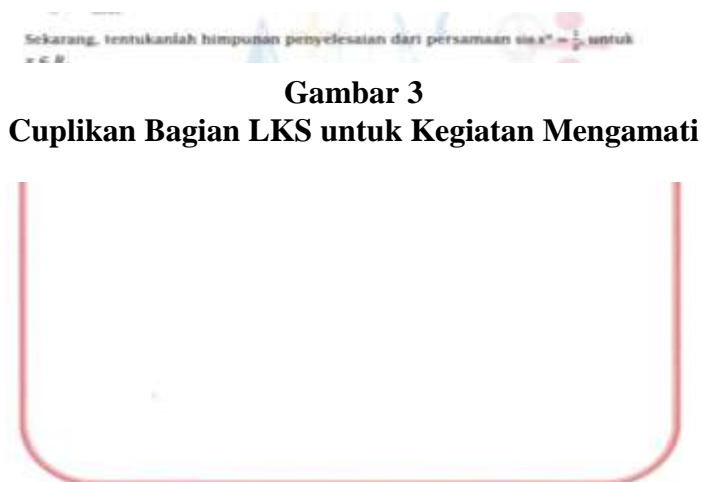


Figure 2
A part of the worksheet for Questioning Activities

c) Trying

From the questions that arose, students were directed to find their own answers to the questions by doing activities that existed on the worksheet. The activity tried to encourage students to find their own concepts of mathematics so that students understood and mastered the concept. If the students have mastered the concept then they could solve the problems given properly and correctly, so that their learning outcomes were good. The trying activities contained in the worksheet based on the scientific approach can be seen in Figure 3.



Gambar 3
Cuplikan Bagian LKS untuk Kegiatan Mengamati

Figure 3
A part of the worksheet for Trying Activities

d) Associating

Associating activities was an activity to analyze and make a conclusion of the results of try activities undertaken. Associating activities encouraged students to summarize concepts acquired at the stage of trying. The worksheet provided a column to make a conclusion as shown in Figure 4.

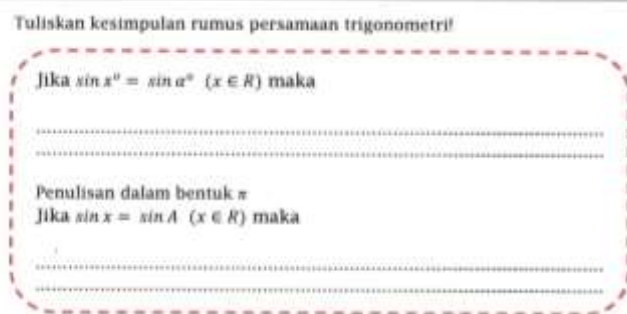


Figure 4
A part of the worksheet for Associating Activities

e) Communicating

Communicating activities trained students to express ideas in both oral and written. Communicating activities also provided an overview of students' understanding of the material they have had learned. One example of the worksheet section that encouraged students to communicate can be seen in Figure 5.

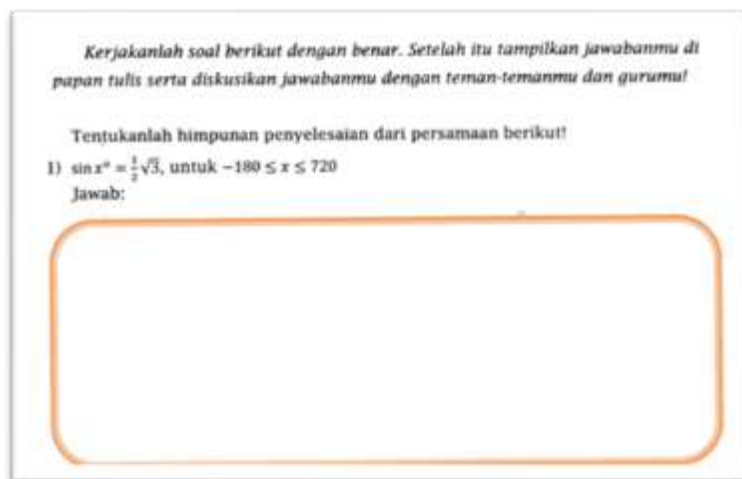


Figure 5
A part of the worksheet for Communicating Activities

Scientific approach activities encouraged students to build their own knowledge. The student was active in learning mathematics. They did not just accept the concept from their teacher, but finds the concept themselves. Students who mastered the concept could complete the questions given correctly so that their learning outcomes became good.

2) Interface (Display)

a) The worksheet Cover

The cover of the worksheet was made simple. The title on the cover of the worksheet was clear. On the cover were pictures that were related to the application of Trigonometry in life. The cover was also equipped with UNP logo and Curriculum 2013. The cover of LKS based on the scientific approach can be seen in Figure 6.



Figure 6
Cover of the worksheet

b) The General Use Instructions Display of the worksheet

The worksheet use instruction was generally aimed at teachers and students using the worksheet. The instruction can be seen in Figure 7.

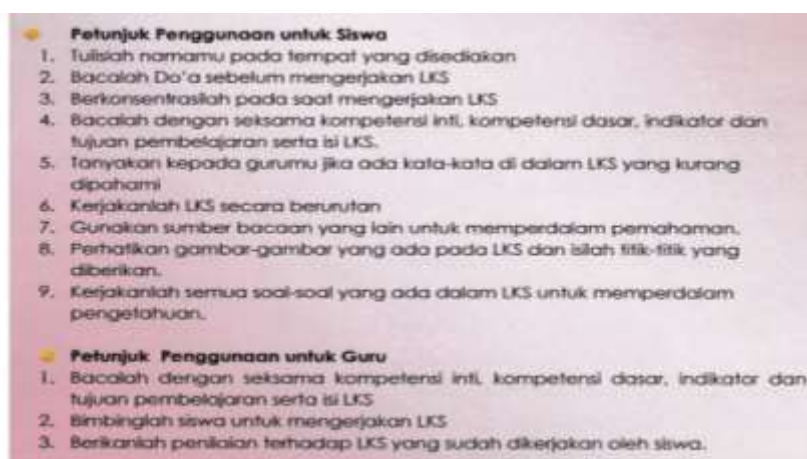


Figure 7
Use instruction of the worksheet

c) Core Competencies and Basic Competencies

The Student Worksheet contained the Core Competencies and Basic Competencies that were adapted to the 2013 curriculum. The Core Competencies and Basic Competencies in the worksheet can be seen in Figure 10.

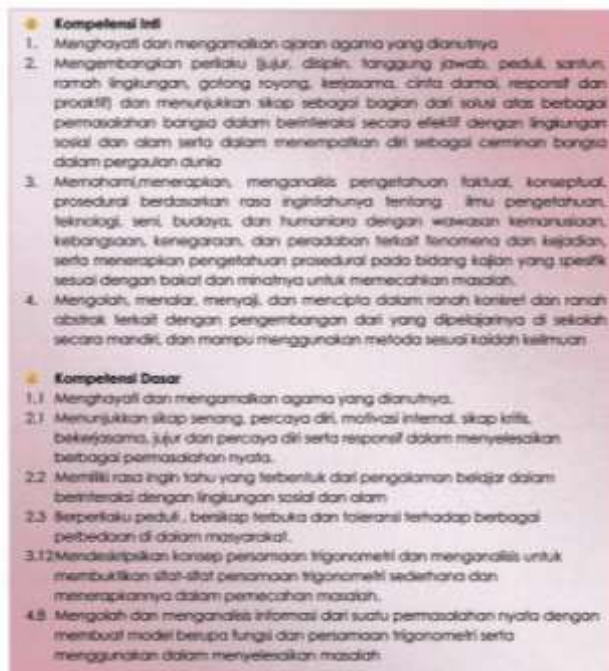


Figure 8
Core Competencies and Basic Competencies of the worksheet

d) Indicators and Learning Objectives

Indicators and learning objectives were in the worksheet for every part. Indicators and learning objectives were developed in accordance with Core Competencies and Basic Competencies. The form of display indicators and learning objectives presented in the LKS-based scientific approach can be seen in Figure 9.

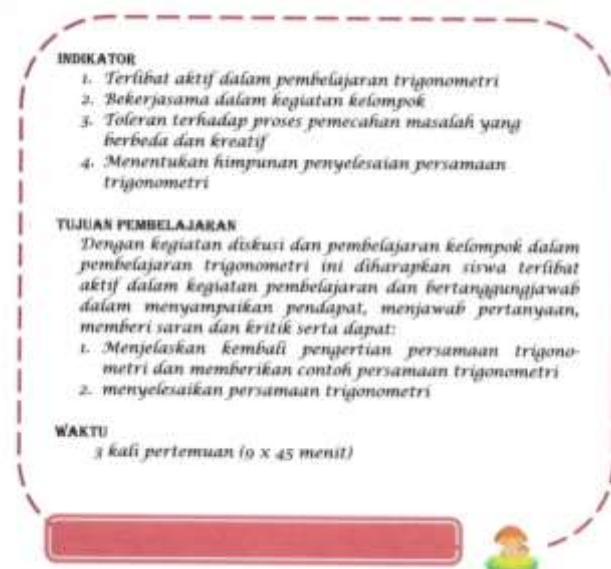


Figure 9
Core Competencies and Basic Competencies worksheet

3) Language and Readability

The third important characters of the worksheet were language and legibility. The language used in this worksheet was Indonesian. The type of writing that was commonly used were a 10pt size Lucida Fax. Mathematical writing on the worksheet used a 12pt type of Cambria Math.

After finishing designing the content, appearance and language, then did self evaluation and expert reviews.

1) Self evaluation

The results of the worksheet design based on the scientific approach were evaluated by researcher herself and friends of mathematics student before it submitted to the mathematics experts. The evaluation was done by reviewing the results of the worksheet design and improving the content of it. In general, the mistakes made at the evaluation were the error of writing and graph layout.

2) Expert Reviews

Expert reviews were needed to test the validity of the developed worksheet. Expert opinions and suggestions were also needed for worksheet improvement. The worksheet was also validated by Indonesian experts. This was conducted so that the language and writing of the worksheet were good and correct. Overall, the validity score for the worksheet approached 85.38% with the category was very valid. This indicated that the worksheet according to Mathematics and Indonesian experts was valid.

Based on the validation from validators, there were some suggestions from validators. The suggestions provided by the validator are generally outlined in Table 1.

Table 1
 Advices from Validators

Validator	Advice
Mathematics Experts	<ol style="list-style-type: none"> 1. On the worksheet page 3, it should not give question about the definition and example of Trigonometric Equations, but give some examples of Trigonometry Equations and asking students to read the book first 2. On page 6, it should not ask students to conclude quickly, but navigate students find formulas to determine the solution of equations $\sin x^\circ = \sin a^\circ$ 3. The word "pada" on page 4 was replaced with the word "berdasarkan" 4. The conclusion on page 7 is not quite right The Formula $x = \dots + (\dots - \dots)$ should be written $x = (\dots - \dots) + \dots$ 5. Did not only perform special angles in the worksheet, but also perform the other angles. And give the trigonometry table to the student. 6. For trigonometric identity material, it should not directly given difficult questions but train students with easy questions first. 7. For example of problem, let just write dots/blank that would student fill and then let the students solve the problem by themselves.
Indonesian Expert	<ol style="list-style-type: none"> 1. Sentence "coba kamu perhatikan" was replaced with the phrase "coba perhatikan" 2. In the worksheet must be noted the command sentence to the students clearly so that students do not hesitate in working on the worksheet.

3.1.2 Prototype 2

Prototype 2 was prototype 1 revised. Prototype 2 was conducted One-to-One evaluation. One-on-One Evaluation was done by asking some students to comment the worksheet. The number of students used in One-to-One evaluation was 3 persons. Each student was given the worksheet then asked them to read the worksheet. Then the researchers observed and recorded responses and student questions about the worksheet.

On One-to-One evaluations, students gave some suggestions and criticism. There were students who claimed that they had difficulty in reading certain types of writing on the worksheet. Students also suggested that it should be given a little entertainment in the worksheet as a cartoon drawing so students did not get tired and bored of reading the worksheet. Another suggestion was that the explanations contained in the worksheet were clear so that they can understand.

3.1.3 Prototype 3

Prototype 3 was prototype 2 revised. Prototype 3 was done Field test. Field test was done by giving the worksheet to student class X.IA2. Here are the results of data collection on field tests.

1) Results of Questionnaire

Questionnaires were given to teachers and students. The practicality values obtained from student and teacher questionnaires are 81.67% and 88%, respectively, in very practical categories. This suggests that the worksheet is already practical.

2) Observation Results

Observation was done every meeting in class. Observation was done to see the implementation of learning by using the worksheet, sufficiency of time and constraints faced in learning.

Observations at the first meeting showed that students were very enthusiastic when receiving the worksheet. For the first Meeting students did the worksheet part 1. The student did it in pairs. This was adjusted to the situation in class X.IA2 where students sit with a partner who has been determined by the teacher in accordance with their abilities.

Based on observations at the first meeting obtained some notes. The worksheet could be understood by the students. In observing activities students take a long time to observe the graph. The time available is not enough to do the worksheet. This happens because the exercise question is too much that is 10 questions and some problems have a high degree of difficulty. Improvements made after this first observation was to reduce the question of exercise into 5 questions. The other five questions are about Homework. At the first meeting students need a lot of guidance from teachers in working on the worksheet.

At the second and third meetings students began to get used to the worksheet so that not many obstacles were found. Students who ask about worksheet instructions are no longer available. The time allocated is enough to work on the worksheet.

At the fourth meeting students learn about the identity of trigonometry. Based on the observation, it could be seen that the guidance on the worksheet was clear and understandable. The time spent on doing the worksheet was sufficient. Students could understand the material and work on existing activities in the worksheet. The material about trigonometric identity was not too much and easy to understand. The exercises about trigonometric identity were quite difficult, therefore in doing the existing exercises in the worksheet students need guidance and instruction teachers.

At the fifth meeting students learn about Trigonometric Applications. In learning there are not many obstacles that arise. The instructions in the worksheet were clear. The images presented in the worksheet were clear and understandable.

Based on the observation it can be seen that the use of the worksheet is getting better in every meeting. This shows that the implementation of learning by using the worksheet gone well.

3) Interview Result

Students were asked to give their opinion about the worksheet. Based on the results of interviews generally obtained information that the time allocated for working out the worksheet is enough, worksheet already has the usefulness for students and easy worksheet in its use. Interview results are also used as suggestions and inputs to improve the worksheet.

3.3. Result of Assessment Stage Analysis

Assessment stage was done to test the effectiveness of the product. At the assessment stage, the worksheet was applied in the learning process. Based on the research conducted, the worksheet was applied for five meetings and one meeting for final test. The effectiveness of the worksheet based on the scientific approach is seen from the final test given to the students. The final test was done after the students finish studying the trigonometry by using the worksheet. The final test results show that the complete student reaches 87.5%. Students who complete the material were more than classical thoroughness of 75%. This means that the LKS-based scientific approach developed has been effective.

4 CONCLUSIONS

Based on the results of research that has been done, it can be concluded that (1) the worksheet based on scientific approach developed was valid according to mathematicians and Indonesian experts. It meant the worksheet has been valid and feasible to use. (2) The worksheet based on the scientific approach developed was practical. The worksheet was easy to use, in accordance with the time allocated for trigonometric material and beneficial for teachers and students. (3) The worksheet has been effective. This was evident from the student's final test result. From the final test result, it is known that 87.5% of students were passed. This indicated that the worksheet has been effective.

5 ACKNOWLEDGEMENT

This research was financially supported by Indonesia Endowment fund for education (LPDP). This study was also supported by Departemen Pendidikan Matematika (Department of Mathematics Education) of Universitas Negeri Padang and Universitas Pendidikan Indonesia. We also acknowledged SMAN 7 Padang for supporting this research.

REFERENCE LIST

- Akker, Jan Van Den dkk. (1999). *Design Approaches and Tools in Education and Training*. Dordrecht: Kluwer Akademic
- Badudu, Yus dan Sutan Muhammad Zain. (1994). *Kamus Umum Bahasa Indonesia (Indonesian Dictionary)*. Jakarta: Pustaka Sinar Harapan
- Depdikbud. (2013). *Pembelajaran Berbasis Kompetensi Mata Pelajaran Matematika (Peminatan) Melalui Pendekatan Saintifik Sekolah Menengah Atas (Competency-Based Mathematics Learning Through High School Educational Science Approach)*. Jakarta: Direktorat Jenderal Pendidikan Dasar dan Menengah .
- Depdiknas. (2008). *Panduan Pengembangan Bahan Ajar (A development Guide of Material Learning)*. Jakarta: Direktorat Pendidikan Dasar dan Menengah.
- McKenney, Susan et al. 2006. *Educational Design Research*. New York: Routledge
- Prastowo, Andi. (2011). *Panduan Kreatif Membuat Bahan Ajar Inovatif (Creative Guide to Create Innovative Instructional Materials)*. Yogyakarta: DIVA Press.
- Riduwan. (2010). *Belajar Mudah Penelitian untuk Guru, Karyawan dan Peneliti Pemula (Learning Research Easily for Teachers, Employees and Beginner Researchers)*. Bandung: Alfabeta.
- Sudijono, Anas. (2011). *Pengantar Evaluasi Pendidikan (ntroduction to Educational Evaluation)*. Jakarta : Raja Grafindo Persada.
- Sugiono. (2012). *Metode Penelitian Pendidikan: Pendekatan Kuantitatif, Kualitatif dan R & D (Educational Research Methods: Quantitative, Qualitative and R & D approach)*. Bandung: Alfabeta
- Sukardi. (2008). *Evaluasi Pendidikan: Prinsip dan Operasionalnya (Educational Evaluation: Principles and Operations)*. Jakarta: Bumi Aksara.
- Trianto. (2010). *Model Pembelajaran Terpadu (Integrated Learning Model)*. Jakarta: Bumi Aksara.