Trigonometry Learning Device Based Guided Discovery For High School Students Of Class X

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Abstract: Guided discovery based learning is one of the instructional models suggested in the 2013 curriculum, as this learning is excellent in assisting the development of students' cognitive abilities. But in practice many teachers have difficulty to implement the learning. This condition is also experienced by teachers of mathematics, whereas of the eight objectives of mathematics learning contained in the curriculum of 2013 four of them related to the cognitive abilities of students. Difficulties occur because most teachers are already comfortable with conventional learning that is generally routine. Conventional learning usually begins with the giving of concepts by the teacher, giving examples of concepts, giving practice according to the next example providing a home task that is also similar to the example. In addition, learning-based learning tools based on discovery of guided learning for mathematics have not been developed. This paper presents guided learning-based mathematics learning materials for trigonometric materials for high school students of class X. This device is obtained through a development study using the Plomp model consisting of three stages: preliminary research stage, development stage and assessment stage. Based on all the steps that have been obtained, the learning tools based on the discovery of guided for trigonometric material for high school students of class X are valid, practical and effective.

Index Terms: development, learning, device, guided discovery.

1 INTRODUCTION

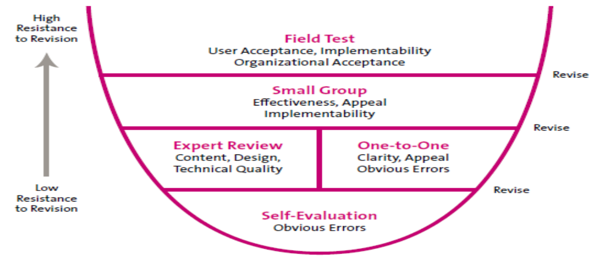
Education has a very important role in determining the quality of human resources (HR). Through education can be developed various potentials that exist in man, such as intelligence, skills and personality or character. For that we need quality education. The quality of education in Indonesia still needs to be improved, because in some international competitions involving 15 years old students Program International Student Assessment (PISA) held every three years, by 2015 Indonesian students are still in an unfavorable sequence of 63 of 72 participants for mathematics. The average achievement of the participants from Indonesia for the year 2015 is 386, still far below the international average of 490. But this result has increased from the previous achievement of the order of 64 out of 65 participants with an average of 375. This increase should continue to be done by increasing quality of mathematics education in Indonesia. The spearhead of improving the quality of education is the implementation of classroom teaching activities by teachers [1]. When paying attention to student achievement in PISA competition for mathematics, the biggest weakness is in reasoning ability, problem solving and communication. These abilities will only be obtained by students if the learning is oriented towards student activities. The reality is that most of the activities in the mathematics classes are still dominated by teachers. Problems faced by teachers in the field is that teachers have been accustomed to teacher-centered learning, where students are placed as passive recipients. Meanwhile, learning tools with instructional model suggested in curriculum 2103, have not been developed. Some teachers who have designed student-oriented learning, in their execution return to routine learning, which starts with conveying concepts, giving examples according to the concept and then providing practice according to the example. This condition often makes students quickly bored so that students' mathematical ability is less developed, students become less independent, and less creative. As a result, although the school administratively uses the 2013 curriculum, but in the implementation of classroom learning is still traditional [2]..Recognizing this reality of the government through the curriculum 2013, provide recommendations for teachers to prioritize the activities and creativity of students in the learning process. To carry out these activities some of the learning models are suggested in the 2013 curriculum, such as guided discovery model with scientific approach. Learning with guided discovery models is learning that allows students to discover concepts through investigation, ask questions, and make conclusions with teacher guidance. According to Borthick & Jones [3] "In discovery learning, learn how to develop a solution strategy, and execute the chosen strategy. In collaborative discovery learning, participants, immersed in a community of practice, solve problems together. "This means that through learning with guided discovery students will be facilitated in improving their potential. According to Harmin and Toth [4], all students are born with five basic skills of dignity, energy, self-management, community and caring. These five basic skills of students can be utilized by teachers in designing learning activities. Dignity, can be utilized by giving students the opportunity to hone their skills in a comfortable way without feeling depressed. Energy, utilizing student energy can be done by not letting them stay seated without any activity. Self-management, giving students the opportunity to choose their own, for example planning the arrangement of group report submission in discussion activities. Community can be done by forming study groups to discuss a particular topic. Caring, can be done by making learning comfortable and not boring, keeping students' attention. This means that teachers can take advantage of the basic potential that students have in making learning planning. As already mentioned one of the learning models recommended in the 2013 curriculum is guided discovery. To apply learning guided discovery in class in general according to Shyah [5] must follow the following stages; (1) Simulation, (2) problem statement, (3) data collection, (4) data processing, (5) verification, and (6) generalitation. Meanwhile, Markaban [6] provides guided discovery steps as follows (1) Formulate problems with sufficient data, (2) organize, proces, and analyze data, (3) construct conjectures analysis, (4) checking conjecture, (5) making correct conjectural decisions, and (6) exercises. Although the two experts provide different names for the steps in the implementation of guided discovery learning, the concept is both the same. The difference is that the steps given by the Shyah only come to the conclusion, while the Markaban after concluding the students are given the opportunity to practice. Practice activities are required in mathematics learning, because one of the characteristics of mathematics is to have an abstract study object. To understand the object of abstract study requires a lot of practice and sincerity. The sincerity is trained in the second to the fifth stage of guided discovery learning. Thus learning with guided discovery matches mathematical characteristics. Based on existing problems required learning tools that can assist teachers in conducting learning activities in the classroom-oriented student activities. In connection with this has been developed guided discovery-based learning tools for trigonometric material for high school students class X through a study. The selection of Trigonometric material is based on its material characteristics that relate much to the principle. This is consistent with the opinion of Marzano [7] which states that topics related to principles can be developed with guided discovery models. Learning tools developed in the form of learning implementation plans for teachers and worksheets for students. The guided discovery step used in the developed device is a step according to the Markaban. The problem that is answered through the research is "how is the design of learning-based learning tools based on discovery for Trigonometry material for valid and practical for class X high school students?"

2 METHODS

This research is a development research, using Plomp model. The Plomp model consists of three phases, namely preliminary research stage, development or prototyping stage, assessment stage [8]. In preliminary research stage activities aimed to obtain information related to the implementation of learning in schools, curriculum used, available tools, and characteristics of students [9]. To obtain data in this first phase, used the instrument in the form of questionnaires, observation sheets and interview guidelines. The second phase is developing a device based on findings in the initial phase. Next the third phase is to test the product. In this paper, we will present the results of the second phase of the research that has been done, namely the process and the result of the development of the tool in the form of learning implementation plan and student worksheet for trigonometric material. The following table provides a summary of the research procedure. To know the quality of the product, during the development process carried out formative evaluation, following the steps based on the Plomp development model, as shown in the

Fase	Activity Description
Preliminary Research	Needs analysis, curriculum analysis, learner analysis, concept analysis.
Development/ Prototyping Phase	Assessment of prototypes in terms of validity, conducted through Self-Evaluation and Expert Review. After being revised according to the standard of validity, it is followed by a practical assessment of student worksheets through One-to-one Evaluation and Small Group Evaluation.
Assessment Phase	Assess whether the product has been practicable and effective through the field test stage. .

figure 1.



Piqure 1. *Formative evaluation stages*

3 FINDINGS AND DISCUSSION

Product Development Process

As explained, in this section the research results for the second phase of the research will be presented. In this phase, the device is developed in the form of learning design and student worksheet. Before designing the device first, the curriculum analysis related to trigonometric material is done. Based on the results of the analysis known for trigonometric material there are three basic competencies that are given for high school students of SMA. In the trigonometric material there are several submictions of trigonometric comparisons on right triangles, trigonometric ratio at preferential angles, polar coordinates and Cartesian coordinates, trigonometric comparison values from angles in all quadrants, trigonometric function graphs, simple trigonometric equations, trigonometric identities , sinus rules, cosine rules, area of triangle trigonometry. Furthermore, based on existing basic competencies formulated indicators for each basic competence then designed lesson plans and student worksheets based on guided discovery. There are several steps in the development phase, first designing early prototypes for lesson plans and student worksheets. The trigonometric material consists of three basic competencies given in 12 lesson hours. So there are three lesson plans for 6 meetings that were made by the prototype. After the initial prototype is completed self-evaluation, at this stage the researchers check the completeness of the device that has been designed include the suitability of materials that have been designed with the curriculum, the fidelity with the steps in the discovery of guided, typo errors and so forth. After the device researcher designed the device according to the product specification formulated, then the designed prototype is given to the expert to be validated. Device validation is performed by three mathematics education experts, one linguist and one technology expert. To the mathematician an opinion related to the suitability of the material to the applicable curriculum and the cognitive level of the students, material demands and suitability of the learning stage with guided discovery model. To the linguists are asked opinions about the grammar used in the designed device. To the technologist asked his opinion related to the graffiti, layout, drawing, font size and color used in the design. The result of this validation is hereinafter called prototype 2.Prototype 2 is a guided invention-based trigonometric learning device that is valid and can be used based on expert judgment. To prove this, then prototype 2 is given to teachers and students at the one-to-one evaluation stage. At this stage the designed device is provided to one teacher and three students. To the teacher is given the design of learning and student worksheets, then asked for his opinion related to the device. Student involved at this stage is one high-ability student, one medium-skilled student and one low-ability student. Selection of students with different abilities is done because in a class there are usually students with different abilities, so that in this way can be known to students' responses to devices developed from various capabilities. Results of student and teacher responses will be used as consideration for the improvement of the developed device. The result of improvement in the one-to-one stage is called prototype 3. Prototype 3 is then used in small group learning. The small group consisted of 6 students, 2 high-ability, 2 medium-skilled and 2 low-ability men. At this stage the teacher teaches based on the design of the lesson, and the students use the worksheet that has been developed. In this small stage, the group is experimented with lesson plans and student worksheets for six meetings. At each meeting examined the problems faced by teachers and students. This problem is used as a consideration to revise the products that have been developed. The result of the revision at the small-group stage is called prototype 4. Next prototype 4 is tested in one of the class in SMA that is class X.9 SMA N 8 Padang by the math teacher who teaches at the school. Based on the input of this field test, the revision is then made to obtain guided discovery based learning tools for trigonometric material that has been categorized valid and practical.

Development Results

The design of learning is made up of three activities: preliminary activities, core activities and closing activities. In the preliminary activities there are activities to open learning, apperception and motivation. In the core activities there are activities that correspond to guided discovery steps. The first step in guided discovery is that learners are asked to formulate the problem with the help of sufficient data. The activities are written in a learning plan to guide teachers in the implementation of learning in the classroom. The following figure is a snippet of teacher activity in the phase of problem formulation to explain the concept of trigonometric comparison ie sinus, cosine and tangent.

II. Core Activities

formulation of the problem with sufficient data 18'

- Educators invite students to the ceremonial field to measure the height of the flagpole and fill in the provided columns according to many experiments performed. on the Worksheet

No	experiment	Distance from the base of the flag to the fulcrum (cm)	High of students (cm)	Angle formed (°)

- Before the students fill in the table first explain how to fill in the table, what needs to be observed, how to observation and what is required for the experiment
- The educator explained that to measure the height of the flagpole it required a bow and measuring instrument such as a meter".
- The educator tells us that in every experiment done by people, different spaces and angles".
- The educator explains that the fulcrum referred to in the table is the learner and the student's height is the height of the learner from foot to eye, because the arc for the angle meter lies parallel to the eye".
- each learner has their respective duties in the group. Some are observers, recorders and who demonstrate it. "-
- After the learner completes the table, the educator tells the learner to return to the class.
- The educator gives an explanation of the trigonometric ratios in a right triangle.
- here the educator explains the trigonometric ratios according to experiments in the field, such as the educator explaining the angular sine obtained by the ratio of the height of the flagpole with the sloping side or the line formed between the bow with the flagpole's top, and so on.

Figure 2.

Teacher activity in the phase of formulating the problemIn the lesson plans are provided activities that teachers can do in the phase of formulating the problem clearly, so that teachers can easily do it. In line with that on the student worksheet is given direction to perform the appropriate activities. In the picture below is provided a snapshot of the activities to formulate the problems contained in the student worksheet.

Activity 1

Do you know how high the flagpole is in our school? Have you ever measured the height of the flagpole? What do you think if estimated, what is the height?

....

....

....

....

....

Well, to find out how high the flagpole is in school, let's do the following experiment!

Let's look at it!

Trigonometry is derived from the Greek word meaning measuring three angles that are related to the angle of the triangle and trigonometric functions such as sinus, cosine and tangent. From one of these functions we can determine the height of the flagpole by using the measuring tool below.

Using an arc like the picture on the side, let's go to the ceremony grounds to find what is known in the table below.

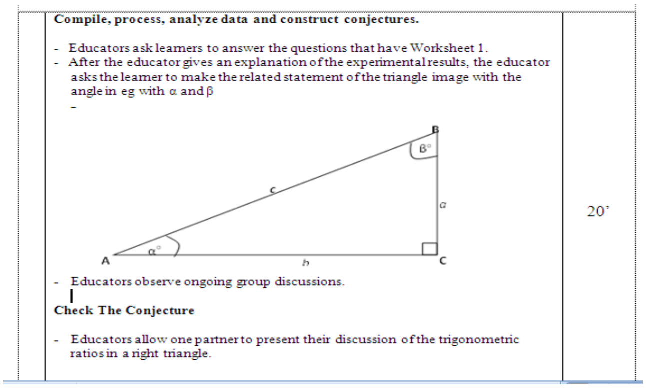
Figure 1

No	Trial	Distance from the base of the flag to the fulcrum (cm)	high of students (cm)	Angle formed (°)

Information:
The fulcrum here is the student.

Figure 3.

Student activity in the phase of formulating the problemFurthermore, learners are guided to discuss with friends in preparing, processing, organizing and analyzing data through the questions contained in the Worksheet. These activities are provided in a snapshot of the following lesson plans and student worksheets.



Compile, process, analyze data and construct conjectures.

- Educators ask learners to answer the questions that have Worksheet 1.
- After the educator gives an explanation of the experimental results, the educator asks the learner to make the related statement of the triangle image with the angle in eg with α and β
-

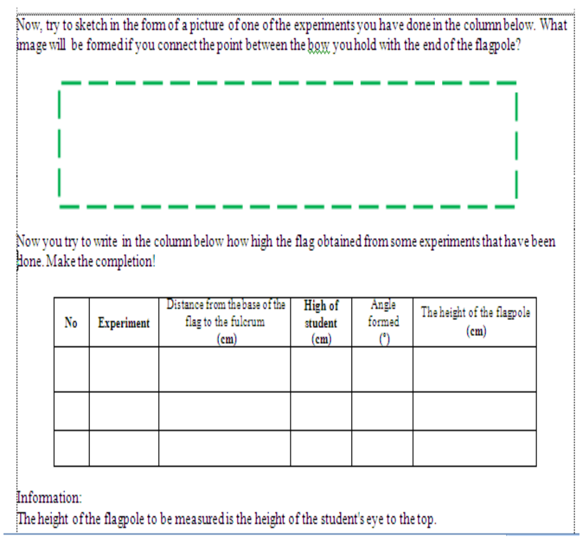
- Educators observe ongoing group discussions.

Check The Conjecture

- Educators allow one partner to present their discussion of the trigonometric ratios in a right triangle.

Figure 4

Teacher activity in phase compiles, processes, analyzes data, constructs the conjecture, and check the conjecture In order for students to perform activities in accordance with the desired, then through student work sheets guided with questions and directions to work. The following figure is a snapshot of activities that students must do at the stage of comparing, processing, analyzing data and constructing constituencies.

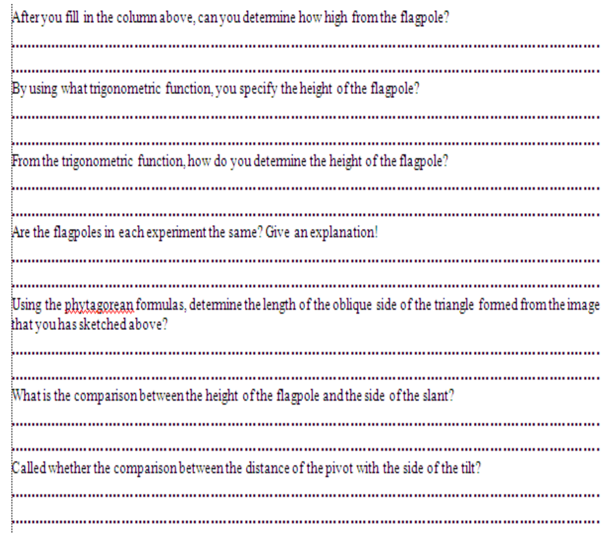


Now, try to sketch in the form of a picture of one of the experiments you have done in the column below. What image will be formed if you connect the point between the bow you hold with the end of the flagpole?

Now you try to write in the column below how high the flag obtained from some experiments that have been done. Make the completion!

No	Experiment	Distance from the base of the flag to the fulcrum (cm)	High of student (cm)	Angle formed (°)	The height of the flagpole (cm)

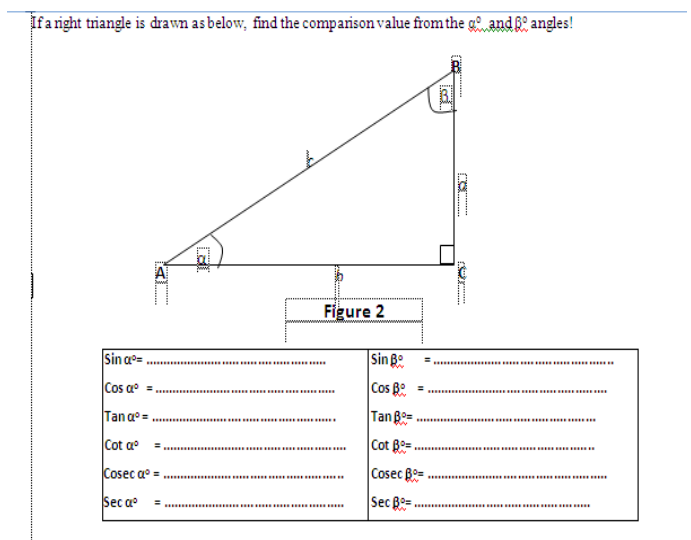
Information:
The height of the flagpole to be measured is the height of the student's eye to the top.



After you fill in the column above, can you determine how high from the flagpole?
....
....
By using what trigonometric function, you specify the height of the flagpole?
....
....
From the trigonometric function, how do you determine the height of the flagpole?
....
....
Are the flagpoles in each experiment the same? Give an explanation!
....
....
Using the phytagorean formulas, determine the length of the oblique side of the triangle formed from the image that you has sketched above?
....
....
What is the comparison between the height of the flagpole and the side of the slant?
....
....
Called whether the comparison between the distance of the pivot with the side of the tilt?
....
....

Figure 5

Student activity in phase compiles, processes, analyzes data, and constructs the conjecture The next step, learners are directed to develop a conjecture or forecast of a given problem. Furthermore, learners and teachers check the conjecture made by the learner, it aims to learners do not experience confusion from the answers obtained.



If a right triangle is drawn as below, find the comparison value from the α° and β° angles!

Sin α°=	Sin β° = ...
Cos α° = ...	Cos β° = ...
Tan α° = ...	Tan β°= ....
Cot α° = ...	Cot β°= ....
Cosec α° = ...	Cosec β°= ....
Sec α° = ...	Sec β°= ....

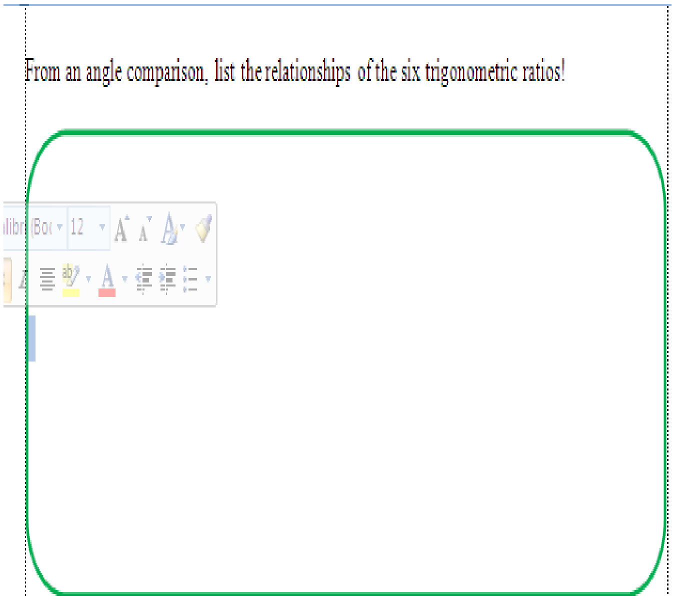
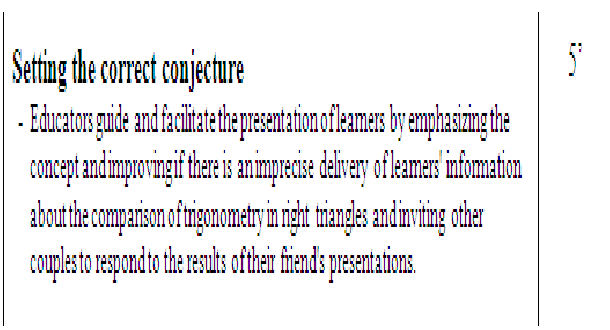


Figure 6.

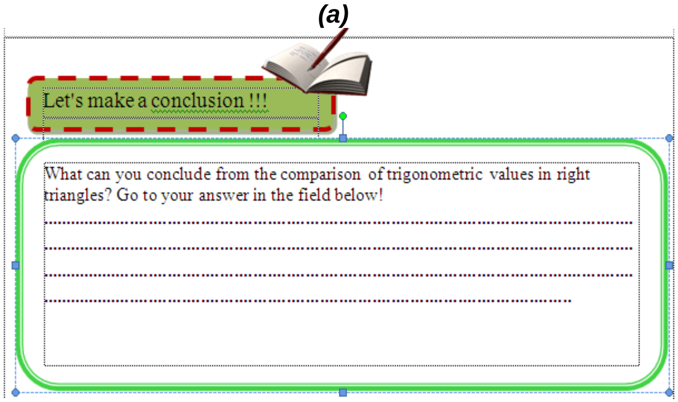
Student activity in phase constructs the conjecture, and check conjectureThrough activities in the phase of constructing and checking conjecture, students will be involved physically and mentally, so it is expected this activity will make students not easy to forget the concept he has gained. In the activity of checking conjecture the teacher directs the students to arrive at the conclusion. The following figure is a phase check for conjectures designed in the lesson plan and in the student worksheet.


Setting the correct conjecture

- Educators guide and facilitate the presentation of learners by emphasizing the concept and improvingif there is an imprecise delivery of learners' information about the comparison of trigonometry in right triangles and inviting other couples to respond to the results of their friend's presentations.

5'

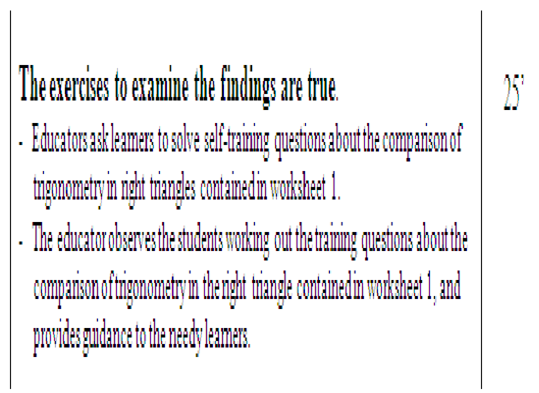
(a)



(b)
Figure 7

(a) Teacher activity in phase Check the conjecture
(b) Student activity in phase check conjecture

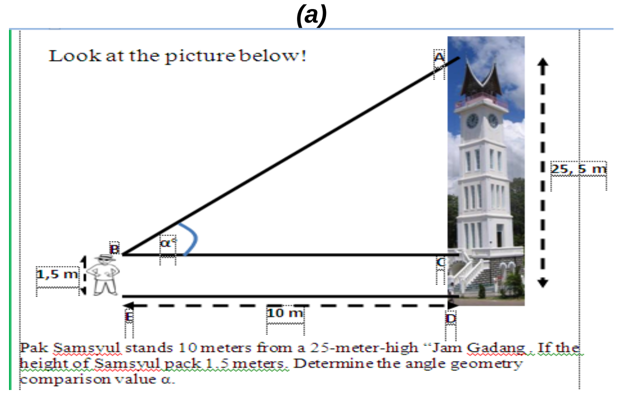
The final activity on the core activities is that the learners are asked to do the exercise questions that aim to examine the results of the invention. This kind of activity will make the concept obtained is not easily forgotten because in the learning of the learner directly involved in the process of discovery of the concepts he learned so that the learning is more meaningful. In closing activities students with teachers make conclusions for the material learned, provide homework and inform the students of the material to be learned at the next meeting. In the picture below is given activities that can be done by teachers and students at the training stage. The results of this development can be used by teachers in teaching trigonometric materials in high school class X. Activity teachers and students who have been designed to assist teachers in implementing student-centered learning. Based on the result of device test, it is known that the mathematical communication ability of students learning with trigonometry based on discovery learning is better than the mathematical communication ability of students who study without designed learning tools. Based on the calculation result, the average of experiment class is 80,48 and the control class average is 74,58 so that experiment class value is higher than control class value. Based on t test obtained t value = 1.85 greater than t table = 1.671. So it can be concluded that discovery-based learning tools are effective to improve students' mathematical communication skills.


The exercises to examine the findings are true.

- Educators ask learners to solve self-training questions about the comparison of trigonometry in right triangles contained in worksheet 1.
- The educator observes the students working out the training questions about the comparison of trigonometry in the right triangle contained in worksheet 1, and provides guidance to the needy learners.

25'

(a)



(b)
Figure 8

(a) Teacher activity in phase give the exercises
(b). Student activity in phase give the exercises

This result corresponds to several studies related to discovery learning. Haohao Wang, Lisa Posey [10] and Maarif.S [11] in his research concluded that through learning-based discovery guided students' math scores increased. This is evident from their ability to construct mathematical proofs logically, using analogy, and the ability to solve more complicated problems by utilizing their own knowledge. Meanwhile B. Tompo et al [12] describes the knowledge gained by guided discovery model shows some advantages. One of them is long remembered by the students because in the discovery model guided students who experienced it themselves. Learning with guided discovery also guides students to discover concepts and familiarize students in solving problems.Yuliani and Saragih [13] through his research concluded that the process of solving student answers to problem solving, conceptual understanding, critical thinking, and mathematical ability of students with guided discovery model is more varied and better. Meanwhile Akhsanul In'am [14] concludes that teachers in these activities become more innovative and teachers' abilities increase. Meanwhile, student learning outcomes use discovery learning and during the execution of learning is very good.Yerizon [1] through his research concludes that discovery learning gives students the opportunity to play an active role in the teaching and learning process and to help students to reach the generalization stage or through the process of induction thinking and mathematical deduction. Similarly, M. Alex Akanmu, et al [15] in his research concluded that guided discovery learning strategies encouraged low, middle and high score students to achieve better results. Meanwhile Koulaei Nejad Jamaloudin, Jafari Nadoshan Somayyeh [16] in his research concluded that guided discovery methods can improve student creativity. Research conducted by Chich-Jen Shieh and Lean Yu [17] concluded that guided discovery models foster the ability of learners in discovery, exploration, problem solving and independent thinking, and creation and discovery through creative discovery or learning.Based on the results achieved through several studies it is known that learning with discovery provides many benefits for students and teachers. So the development of the tools that have been done in this research is very precise and will help overcome the problems that teachers are facing in school.

4 CONCLUTIONS

Based on all activities that had been conductelized and the tool obtained from this study, it can be concluded that :

1. Lesson plan constructed in this study provides activities that can be utilized by teacher for teaching trigonometric comparison according to steps of discovery learning, those are (1) giving an opportunity to student to engage in formulating problem (2) preparing, processing, organizing and analyzing data (3) develop a conjecture or forecast of a given problem, (4) check the conjecture (5) do the exercise that aim to examine the results of the invention.
2. Based on the result of device test, it is known that the mathematical communication ability of students learning with trigonometry based on discovery learning is better than the mathematical communication ability of students who study without designed learning tools. Based on the calculation result, the average of experiment class is 80,48 and the control class average is 74,58 so that experiment class value is higher than control class value. Based on t test obtained t value = 1.85 greater than t table = 1.671. So it can be concluded that discovery-based learning tools are effective to improve students' mathematical communication skills.

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