The Use of Geogebra Software in Improving Student's Mathematical Abilities in Learning Geometry

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Abstract: Learning geometry has not paid attention to aspects of mathematical ability maximally so that learning outcomes are not optimal either. Technology has been developing rapidly, one of which is the emergence of geogebra software version 6.0 which can help the learning process of mathematics but has not been used in learning. This study aimed to determine the magnitude of the increase in mathematics learning activeness and achievement in geometry material using geogebra software. This research was conducted in class IX SMP Negeri 2 Tanjung Morawa, totaling 210 students. The method used is a class action research method which consists of two cycles, the analysis used is descriptive comparative by comparing the data between cycles. Geogebra is used to visualize geometric objects that will be transformed. Through the visualization process students try, reason, and finally find the concept of transformation. The results showed an increase in student activity during learning. The test results for each cycle showed an increase in the number of students who achieved minimum completeness (KKM). At the end of the cycle, students who completed learning reached 85.24%. Based on this, learning using geogebra software can improve mathematical abilities.

1 INTRODUCTION

21st-century learners are familiar to the pictorial culture of learning mathematics as well as other contents via wide access to internet site and various applications that are related to mathematics. In this regard, the traditional lecture-based method of teaching mathematics is not working as expected by mathematics tutors. This could be most of the mathematics teaching and learning which is not aligned to the pictorial culture. The central obstacles in teaching mathematics could be concepts without adequate illustrations (Dahal, 2019).

In Indonesia's curriculum, geometry is one of the essential materials that taught from elementary school until college. It allows people to understand the world by comparing shapes, objects and their connections (Jelatu, 2018).

In facing the challenges of the 4.0 industrial revolution era, an increase in human resources is needed to be able to compete in the international realm. One area that we can use as a bridge to improve quality human resources is education (Adelabu, 2019). One branch of science that plays an important role in education is mathematics. Mathematics as one of the areas of learning in schools is an area that gets attention in the development of learning. Mathematics in junior high school, for example, tends to be abstract. This causes mathematics to be a subject that is considered difficult for students. One part of mathematics that is abstract is geometry.

The need to visualize concepts and support the materials in Mathematics learning by forming the pictures or by using existing draw, becoming what is needed by the students in improving their mathematical development and understanding. GeoGebra can combine dynamic visualization of geometry and the results of mathematical calculations simultaneously (Sur, 2020).

Technology developments rapidly bring new challenges in education. New technology has capability to make change in education. Many people already use and explore the new and existing technology for greater benefit of education. Putra (2012) in his book stated that it's not chalk and talk anymore, but (more) to school approach to developing student's digital literacy.

With the progress in the technological change process in the education field, we ought to admit that the mobile education is a part of a new scene. It

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provides personal distant learning, non-official learning and automatic learning through the use of mobile devices by students of all ages and backgrounds. It enables them to interact, cooperate and learn through different ways (Alkhateeb, 2019).

Long before, in year 2002, UNESCO has advocated the use of technology in education. This trend is still continuing until today, as recently Leung (2016), Oktaviyanthi and Supriyani (2015), Loong (2014) and Saadati (2014) exploring the use of technology in regard to learning and education. Specifically, Fathurrohman and Porter (2012) advocate the use of technology for mathematics teachers. Recently in year 2017 they explain the teachers' real and perceived of technology availability for teaching and learning, while Hatlevik, Throndsen, Loi and Gudmundsdottir (2018) explain the students believe and their actual achievements in regard to ICT experiences. Vongkulluksn, Xie, and Bowman (2017) argues on teacher belief as one of important factors in technology integration. Karadeniz and Thompson (2018) proposed the use of calculator, and Wares (2018) argues on the use of dynamic geometry, while in particular, Martinovski (2013), Quinlan (2016), Segal, Stupel, & Oxman (2016), States & Odom (2016) promoting GeoGebra as a tool for technology use in mathematics teaching and learning.

Either science or technology is believed can provide a great opportunity for students to do a deep exploration of their understanding about a certain concept. Some technology-based learning tools that usually used during university level mathematics learning such as Maple, Matlab, GeoGebra, SPSS, or Fluent, the needs to find effective and efficient software to assist them in doing a better understanding still become educators' top concern (Safrida, 2018).

One of mathematics concepts is geometry. Atiah in Hoherwarter and Jones (2007) said it is important to learn geometry and algebraic geometry. Geometry concepts and the ideas of geometry have been introduced to students since their study in elementary school level, for example for the introduction of line, plane and space. However, many geometry concepts and ideas in high school level presented in the abstract concept for students, not in concrete as before. This is one of the reasons why the students still get some difficulty when learn geometry. Quadrilateral is a mathematics concept in geometry for junior high school level. Quadrilateral topic consists of concept and definitions of abstract geometry that is required to solve problems related with geometry use in daily life. It is acknowledged that the students' cognitive development at the stage of junior high school age is the formal-operational stage. At this stage, the student should have the capacity to use abstract principles, so that students must be able to learn abstract learning materials such as Quadrilateral. Kabaca (2017) provided classroom note for understanding geometry, however it is not enough for this case.

Written in the Regulation of the Minister of National Education No. 16/2007 emphasized that one of the pedagogical competencies that SMP / MTs mathematics subject teachers must have is to be able to utilize information and communication technology for learning purposes. Meanwhile, for professional competence, teachers must be able to take advantage of Information and Communication Technology (ICT) to communicate and develop themselves. The main application of technology in learning Mathematics is the integration of software (software) for learning Mathematics. This has led to a lot of software being developed and utilized.

According to Sumeda (Bawono, 2015) mathematics is generally defined as a field of science that studies the patterns of structure, change and space of life, because in every daily activity, whether it is based on it or not, we definitely use mathematics. Mathematics equips students to be systematic, critical and creative, therefore mathematics must be mastered by everyone.

However, based on the 2011 TIMMS report, Indonesian grade IX students occupy the 38th position among 42 countries participating in the math test with an average score of 406 while the international standard standard score is 500. The TIMMS survey results regarding the mathematical abilities of Indonesian students are not much different from the results of surveys from other institutions such as PISA (Programme International for Student Assesment). Based on the results of the 2012 PISA survey, Indonesian students' mathematical abilities rank 64 out of 65 countries with an average score of 375, while the average international score set by PISA is 494.

The domain of the question content in the PISA test is geometry. The content sub-components tested are changes and linkages, space and form, quantity, uncertainty and data. Many geometric problems require visualization in problem solving and in general students find it difficult to construct geometrical spatial shapes, as experienced by students at SMPN 2 Tanjung Morawa.

One of the efforts to visualize mathematical ideas so that mathematics can be understood by students, especially on geometry material, is through more innovative learning strategies. Among them are

innovative media with the use of advances in Information and Communication Technology (ICT) in the form of geographic media as a learning resource and learning media.

Computer programs can be used as an alternative-effective solution. One of the computer programs that can be freely used is GeoGebra. GeoGebra is Non-Commercial Free Software for use by mathematics educators (teachers and lecturers) in Indonesia. The use of GeoGebra in mathematics teaching and learning enable students to draw geometry objects in fast and specific. Enable to animate and manipulate visual to understand geometry concept, evaluating, to study geometry object (Syahbana, 2016). Many researches show positive effects of teaching and learning with GeoGebra, such as Zengin, Y (2017) and Hähkiöniemi, M., (2017).

Geogebra is software designed to solve geometry, calculus and algebra material as well as applications fordesigning spaces and buildings (Saputra, 2019). It can serve for development of instructional materials in mathematics in many different forms, types and styles, and for all levels of mathematical education. It is free to be downloaded form a website, while nothing but a Java 6 platform is necessary for its full operation. GeoGebra seems to be particularly easy and intuitive to learn. Files can be saved in ".ggb" format, or as dynamic web pages. GeoGebra can output files as pictures (.png) or as encapsulated postscript for publication quality illustrations.

GeoGebra user interface offers a rich graphics menu for drawing various objects, while the complete construction protocol is saved and it appears in any chosen language from the available 45 versions, therefore no translation is necessary and free sharing of developed instructional materials is genuinely supported all over the world. Users are encouraged to visit GeoGebra webpage and GeoGebra user's forum GeoGebraWiki, a free pool of teaching materials for this dynamic mathematics software where everyone can contribute and upload materials. GeoGebra has a built-in Cartesian coordinate system, and accepts both geometric commands (drawing a line through two given points, a conic section determined) and algebraic ones (drawing a curve with a given equation). Among its more interesting features is the ability to draw tangent lines to algebraic and even transcendental curves at given points, while equation of this tangent line is available immediately too. This double representation: the geometric-synthetic one and the algebraic-analytic one is one of the greatest advantages of GeoGebra software that mostly suits to didactic aims of full comprehension of basic mathematical concepts.

GeoGebra software can be installed on a personal computers, android devices, and direct use on the web anytime and anywhere. In addition, the '.ggb' file extension, as outcomes of the learning process using GeoGebra, can be stored and disseminated for the next session of learning. This output file is commonly called the GeoGebra Applet. This is one of features in GeoGebra that can be used, modified, and/or developed by educators for dynamic and interactive mathematics teaching and learning.

Publications, there is no GeoGebra Applets closely linked and aligned to the Indonesia national curriculum in accordance to the mandated approach. The availability would be benefit for mathematics teaching and learning and the implementation of the national curriculum. In addition, various discovery learning activities can be carried out, by using the GeoGebra Applet. For that reason, there is a need to develop GeoGebra Applet closely linked and aligned to the Indonesia national curriculum, in this case is to facilitate the mathematics teaching and learning in quadrilateral concept, in accordance to the scientific approach.

GeoGebra separates mathematical objects into free objects and dependent objects. Where the dependent objects are defined by an explicit construction (algebraic or geometric) the construction steps can be encapsulated into a tool. Once the tool has been defined a new button appears on the tool bar and a corresponding function name is available to the user. Such tools are essentially functions, and may operate with geometric objects such as circles, lines and points. The tools function within GeoGebra is interesting because it allows geometrical functions to be defined, which illustrate a key mathematical process: encapsulation or compression. Using these tools it is possible to extend the software in natural ways, just as mathematical domains are extended during normal teaching.

The Indonesia national curriculum, called year 2013 curriculum, mandates the essence of scientific approach in teaching and learning, including for mathematics. Through a scientific approach (observing, questioning, associating, experimenting, and networking stages), the students are directed to establish the ability to thinking scientifically that emphasizes inductive reasoning rather than deductive, and guiding the students to research, instead of being told. At the time of research project, checked through available

According to Aliviah (2012) during this time the learning of geometry in the classroom was only taught using whiteboard media and not yet utilizing learning media such as computers. The submission of

material that is often done by the teacher is conventional learning such as lectures, so that there are students who have difficulty understanding the material presented. For this it is necessary that other media can help students understand the geometry. One of the technology-based mathematics learning media that can help students to represent mathematical problems is GeoGebra software. One of the learning media that can represent a mathematical model or represent a linear equation of two variables into the form of graph using the help of GeoGebra software media. According to Hohenwarter et al (2008) GeoGebra is a dynamic mathematical software that combines geometry, algebra, and calculus.

Meanwhile, according to Wulandari (2015) GeoGebra is an easy-to-use mathematical software, both on geometry, algebraic, and calculus material. From some of the definitions of GeoGebra above it can be concluded that GeoGebra is one of the mathematical software that can be used in learning mathematics that includes material geometry, algebra, and calculus. GeoGebra serves as a math learning medium that can visually help students to understand abstract mathematics material. Not only that GeoGebra can also help students in understanding the concept of straight line graphs in more detail with a varied and interesting look. In addition to the teachers themselves, GeoGebra can be used as a math learning tool to create interactive learning that allows students to explore various mathematical concepts that are abstract.

Furthermore, according to Preiner (2008), "Computer algebra systems, dynamic geometry software, and spreadsheetsare the main types of educational software currently used for mathematicsteaching and learning. Each of the programs has its own advantages and isespecially useful for treating a certain selection of mathematical topics orsupports certain instructional approaches ".

Geogebra Software is one of the technology products that are widely used in mathematics learning. This Software is widely utilized as a tool to construct, demonstrate or visualize abstract problems in mathematics that can not be resolved manually especially in the field of geometry.

Apart from the standalone application, GeoGebra also allows the creation of interactive web pages with embedded java applets. These targeted learning and demonstration environments are freely shared by mathematics educators on collaborative online platforms like the GeoGebraWiki. The number of visitors to the GeoGebra website has increased since 2004 from 2000 per month to over 300,000 per month coming from over 180 countries.

The International GeoGebra institute has been established, coordinating the work of thousands of volunteers all over the world in the structure of accredited national GeoGebra institutes in different countries. GeoGebra dynamic spreadsheets enable to produce interactive presentations directly on the web serving as electronic instructional sources for e-learning solutions in the form of dynamic cognitive tools. These html pages can be used directly from Internet and are presentable in all common web-browsers, while there is no need to install GeoGebra software in the user's computer. The only necessary prerequisite in addition to the web-browser is the installed Java support that is essential.

Based on exposure to background problems, the problem is obtained in this research activity is, whether the use of software GeoGebra media can improve the mathematical ability of class IX students. From the formula above, the purpose of this research activity is to know whether the use of media software GeoGebra can improve the mathematical ability of junior high school students 2 Tanjung Morawa class IX.

2 LITERATURE

Understanding geometry is important to yourself and to understand other areas of mathematics. Geometry is the study of the relationships between points, lines, surfaces, angles, and shapes. So naturally, drawing diagrams is a must! The relationships, properties, and theorems will be easier to understand when you have a diagram! ... Just be sure to pay attention to the proportion of lines and angles. When you start studying geometry, it is important to know and understand some basic concepts.

Geometry comes from the Greek meaning 'earth measurement' and is the visual study of shapes, sizes and patterns, and how they fit together in space. You will find that our geometry pages contain lots of diagrams to help you understand the subject. When you're faced with a problem involving geometry, it can be very helpful to draw yourself a diagram (Pamungkas, 2019).

Geogebra is one of software to visualize and demonstrate mathematical concepts, especially geometry and algebra. Geogebra is recommended to be included in the school curriculum because it has potential in mathematics education. For this function, students can use algebraic and geometrical functions

simultaneously with interactive dynamics that will enhance their cognitive abilities (Zetriuslita, 2020).

Various benefits of computer program application in mathematics learning is expressed by Kusumah (2003). According to him, computer programs are ideal to be used in learning mathematical concepts that demand high accuracy, repetitive concepts or principles, precise, fast, and accurate chart completion. Furthermore Kusumah (2003) also suggested that the innovation of learning with computer assistance is very good to be integrated in learning mathematical concepts, especially those involving the transformation of geometry, calculus, statistics, and graphs of functions.

Computer utilization in mathematics learning is intended to support and facilitate students in understanding mathematical concepts. Thus, understanding the concept of students should get a top priority instead of only increasing the mechanistic ability of students in utilizing computer programs. In this case teacher teaching is indispensable to associate a variety of animation or application of computer programs produced by students with relevant and underlying concepts. In many ways, understanding the concept must precede various computer program utilization. However, within certain boundaries, computer programs can be utilized in the process of the concept of constructlifing by students. Although based on its functionality, computer learning media can be applied to enhance students ' mathematical skills, and to construct concept mastery skills.

Hohenwarter (2008) said the GeoGebra program is very beneficial for both teachers and students. Unlike the use of commercial software that usually only bias used in schools, Geogebra can be installed on personal computers and utilized when and anywhere by students. For teachers, GeoGebra offers an effective opportunity to create an interactive online learning environment that allows students to explore various mathematical concepts.

3 METHOD

This research was conducted in SMPN 2 Tanjung Morawa, Class IX with 210 students. This research method is Classroom ation research. The subjects of the study were students of class IX 1-year semester 2020/2021 lessons of 210 students. The Data examined in this class action study is the guidance of student learning and the mathematical abilities of students in the learning process. Data is collected using a document technique from the pretests result as an initial condition. The guidance of learning is derived from the students' mathematical ability to solve geometry problems through phase I cycle test and cycle II. The data that has been collected is then analyzed using two ways: quantitative data of learning results Analyzed with comparative descriptive, which compares the value of learning outcomes in initial conditions, cycle I, and cycle II. Qualitative Data of the learning process as a description of student percentage in the mathematical skills of students are analyzed with qualitative descriptive. Qualitative Data compared between initial conditions, cycle I, and cycle II. The research procedure can be seen in Figure 1.

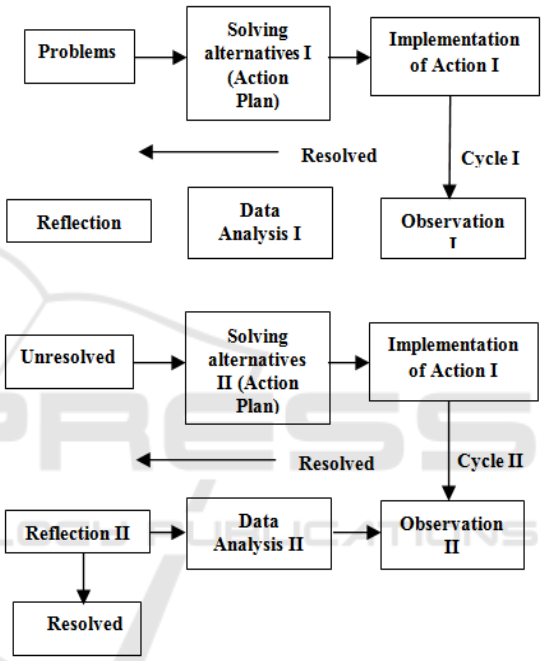

Figure 1: Research procedure Diagram.

Based on Figure 1 shows that the research process is conducted with two cycles that contain aspects of planning, action, observation, and reflection. Planning research activities include identifying issues, drafting a learning Implementation plan for each action activity, student worksheets, evaluation and media tools, tools and materials needed in learning, and forming randomly-generated groups. Action includes preliminary, core and closing activities. Observation of learning activities is conducted during the implementation of teaching and learning activities to know the course of learning. At the end of the cycle ends with tests. Based on observation and test result, the next stage can be done. Data gathered from observation results include study results data, learning process data in the classroom,

and observation data from completion of student worksheets in view of students ' mathematical skills.

The reflection in this class action study is an attempt to assess what has happened, or that has not been completed in a previous step or attempt. The results of reflection were used to take further steps in an effort to achieve research objectives. Data obtained from the observation, analyzed and evaluated with the teacher observer. The findings may still not be maximized, need to get noticed for the next meeting. Reflection activities include knowing the number of students who have a value below the minimum completeness criteria, constraints experienced by students and teachers and the possibility of increasing the level of understanding.

4 RESULTS AND DISCUSSIONS

4.1 Initial Conditions

Prior to the commencement of the research, the learning carried out only used the lecture method and only occasionally used the discussion method. Teachers often explain all material orally without using other learning models, teaching aids, and software used in mathematics that can arouse student interest in learning. Students not interested in learning mathematics resulted in students being less active in the learning process. The inactivity of students is caused by students only listening without being actively involved in the learning process.

Students only take notes without asking many questions so that their level of understanding is not known. At the end of the lesson each material is tested and the results are many students whose scores are below the KKM as shown in Figure 2 below:

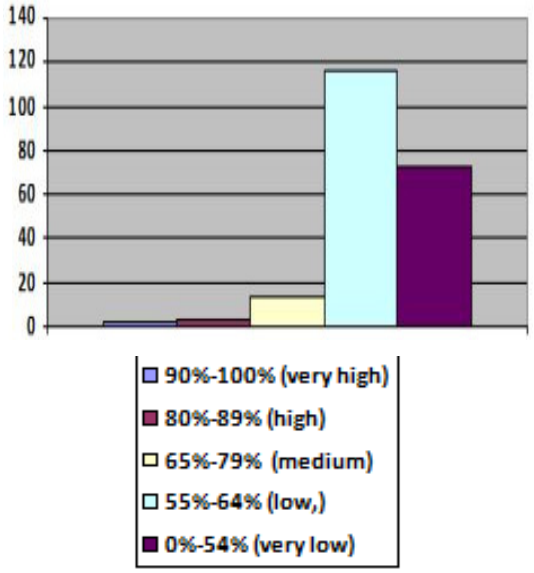

Figure 2: Pretest Students Math Skills.

This is because students memorize more material so that most students are unable to solve math problems correctly. Learning using geogebra software will be easier for students to solve geometry problems. The discovery of geometric concepts in the previous year was mostly done manually. The application of the lecture model was felt to be less attractive to students' interest and activity. Thus learning has not met the desired standards, corrective steps are needed.

The learning outcomes showed that 21 out of 210 students (10%) had completed their mathematical abilities, while 189 other students (90%) had not yet reached the KKM. In graph 2, it can be seen that the results of daily tests are directly proportional to students' mathematical abilities in the learning process. Learning outcomes will increase if students are taught using geogebra software in the learning process of geometry material.

4.2 Description of Research on Cycle I

After the learning action carried out in cycle I, the researcher identified the problems that were found during the learning. Based on the results of observations and observations of researchers during the learning process, there are several things that are considered by researchers so that they become material for improvement for the next cycle, namely:

a. Students did not understand the use of geogebra software after teaching in cycle I, so it is necessary to re-teach using the geogebra

software, so that students are able to solve geogebra questions correctly.

b. The mathematical ability of students in solving the problems in the first cycle that had not reached the completeness level was 97 students or 46.19%, while the students who had reached the completeness level were 113 students or 53.81%. Thus it can be said that the class has not finished solving geometry problems, namely that there are not ≥ 80% of students who have a complete level of mathematical ability in cycle I.

The following is presented in graph 3, the students' mathematical abilities in cycle I are as follows:

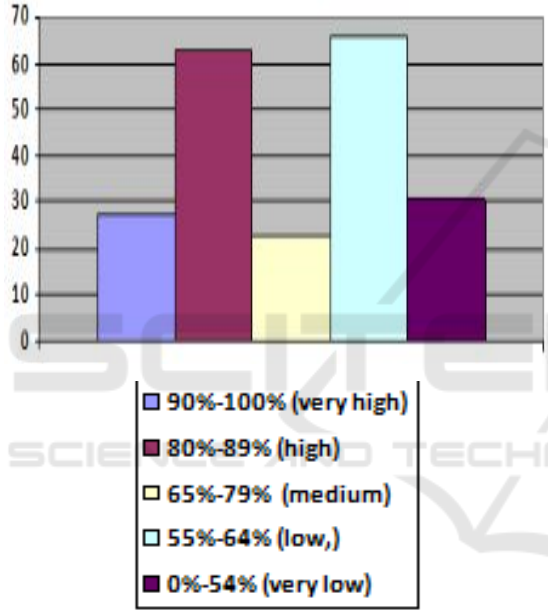

Figure 3: Student mathematical skills on the I cycle.

4.3 Description of Research on Cycle II

After carrying out the learning action in cycle II it was found that the students' mathematical abilities had improved from before. This can be seen from:

a. The mathematical ability of students in solving problems in cycle II with a very high level of ability was 35 students or 16.67%, high ability levels were 46 students or 21.90%, medium ability levels were 98 students or 46.67%, low ability level as many as 16 students or 7.62%, and very low ability level as many as 15 students or 7.14%. Meanwhile, students who have reached the completeness level are 179 students or 85.24%. Thus it can be said that the average grade IX student has completed solving geometry problems, namely there are ≥ 80% of students who have a level of completeness. Mathematical abilities in cycle II can be seen in the graph below:

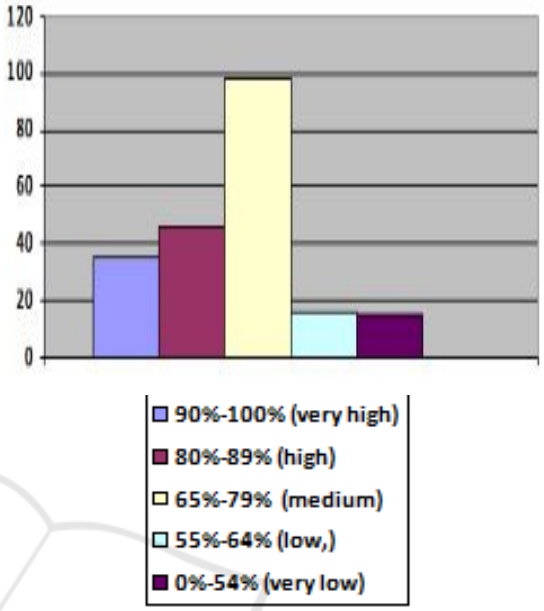

Figure 4: Mathematical abilities of students on cycle II.

b. From graph 4 can be seen that there is an increase in the number of students who reach the level of completeness on geometry material using geogebra software in cycle II is 85.24%, whereas in cycle I the level of completeness of students' mathematical abilities was obtained at 53.81%. So the increase in the completeness of students' mathematical abilities from cycle I to cycle II was 31.43%.

Some students are still not able to solve the given questions, but the number of students who have not been able to solve the questions has decreased from before. This can be seen from the results of students' mathematical ability tests in cycle II.

From the results of data analysis, it can be concluded that students' mathematical abilities have increased and students have reached the expected level of learning completeness. This shows the success of learning action in cycle II.

Based on the explanation above, from the initial conditions to the final conditions in cycle II, many students were active in following the learning process

due to the use of geogebra applications in solving geometry problems.

5 CONCLUSION AND SUGGESTION

5.1 Conclusion

Based on the results of the research and discussion, the conclusion is that: Learning using Geogebra software can improve students' mathematical abilities and the number of students who have reached the KKM on geometry material after using geogebra software from initial conditions to cycle I and cycle I to cycle II increases.
Therefore, geogebra software can be used in the learning process on the subject of geometry and other subjects that have the same characteristics.

5.2 Suggestion

From the results of this study, the advice that I can give to school principals and mathematics teachers at SMP Negeri 2 Tanjung Morawa, should be in the teaching and learning process of mathematics teachers also use mathematics learning software to be able to improve students' abilities in learning mathematics.

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