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GeoGebra Application Utilization in Computer-Based Interactive Instructional Media Development Oriented of Creative Problem Solving Model

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Abstract: Describing the design of GeoGebra application utilization in the development of computer-based interactive instructional media oriented creative problem solving model is the purpose of this research. This research used 4-D research and development model (define, design, develop and disseminate) but in this research was only limited until design stage. Qualitative descriptive data analysis technique was a technique of data analysis in this research. The results of this study indicated that interactive learning media oriented creative problem solving model was designed in according to the initial needs, curriculum, materials, literature and mathematical ability of students. This instructional media was designed specifically to encourage student understand the concept of learning materials in more depth. Full features of the GeoGebra application program were utilized to design instructional media which in its used can involve students directly on demonstration process. This learning media was supported by the instructional concept which student centre approach that help student in learning abstract mathematics objects. This instructional media was designed specifically in order to be applied by students who had high, medium or low mathematical ability, so that, each individual student will be able to creativity in building new knowledge by their own thinking style.

Key words: Creative problem solving, GeoGebra, computer-based, interactive, design, disseminate

INTRODUCTION

Mathematics is study of abstract objects. This abstract nature has the capacity to encourage confusion and difficulty in mathematics learning, especially for students who are not accustomed of abstract thinking. This potentially raises necessities in the application of instructional media that is able to build a unique experience for each student when connecting with math subjects whose objects are abstract. As the development of science and technology increasingly rapidly and sophisticated that potentially encourage each individual to do many useful things then in carrying of various activities can be easily while carrying it out. That statement was following the opinion by Divayana *et al.* (2017) which in principle states that the role of technology in the era of globalization is vital in encouraging every individual in society to carry out activities creatively, quickly and efficiently.

The benefits of this development also greatly affect the development of various aspects in education. The rise of various technological developments that can facilitate the tasks in the educational development, automatically support the mathematics learning in the form of mathematical instructional media. According to Divayana *et al.* (2016) instructional media is anything that can be used to transfer the message (learning materials) so, it can stimulate the attention, interest thought and feelings of students in activities learning to achieve learning goals.

Those statements following the opinion by Wiana *et al.* (2018) which in principle states that the presence of instructional media for increase student interest to learn effectively. The opinions by Alsadhan *et al.* (2014) also support the opinions expressed above concerning the use of current instructional media appropriately done to transfer interactive teaching materials to stimulate student's

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interest to learn effectively with an interesting learning style. All statements about the above instructional media are also supported by Xia (2018) which in principle states that through the learning media students can learn more actively, independently and more flexible in utilizing the learning space and learning time.

The use of mathematical instructional media can expose and provide a tangible form in supporting to build mathematical concepts. Various forms of computer application program that currently has developed rapidly are one of the technological developments that can be utilized as a relevant instructional media. One of the computer application programs that can be utilized as a mathematical instructional media is GeoGebra. GeoGebra is dynamic mathematical software that can be used as a tool in mathematics learning. This software is developed for the mathematics learning process in schools that observed at least there are three uses such as media learning mathematics, tools to make mathematics learning materials, solve math problems. This program can be utilized to improve student's understanding of the concepts which they have learned and as a medium for introducing or constructing new concepts (Nur, 2016).

GeoGebra has a variety of facilities that can be utilized not only just to develop a medium of visual mathematics learning. However, it can be used to compose an computer-based interactive instructional media. Computer-based interactive instructional media that is intended is instructional media which can be simulated directly by students. The formation of computer-based interactive instructional media requires a student-oriented concept. This is because each student is unique which the necessity of each individual is different. Thus, it is necessary to perform a more innovative, contextual, non-boring instructional media development and the most important is the students can be directly involved in using this media. So that, students can use the knowledge they have to guide students in building new knowledge and of course it will be able to attract student's interest to actively search solutions of solving problems from the problems that connected with mathematical concepts. One of the computer-based interactive instructional media developments that can be developed is the computer-based interactive instructional media development oriented of creative problem solving model. The computer-based interactive instructional media oriented of creative problem solving model that be mean is instructional media that be oriented in accordance by the syntax of creative problem solving model. According to Sugiharni (2015) creative problem solving learning model is a learning model that focuses on learning and skills problem-solving that be followed by strengthening skills. Students can perform problem solving skills when be confronted with a question. They can choose and develop their thought ideas, so, it is not only centered by memorizing without thinking. Problem solving skills will extend the thinking process of students.

This research refers some related research results about the instructional media development to enrich the discussion and the study of researcher. As for the research results on the utilized of GeoGebra in geometry learning have in similarities with researcher in terms of utilization of GeoGebra applications. While the difference is the output/product which be produced. Wihardjo *et al.* (2016) used GeoGebra utilization to know the difference between student's learning result which was taught using GeoGebra with student who taught was not using GeoGebra while researcher use GeoGebra utilization to make interactive instructional media. As for the constraint of research that was conducted by Wihardjo *et al.* (2016) was in the activities learning there was no motivation to utilize computer application programs especially GeoGebra. The research results on the use of creative problem solving model in mathematics learning (Pratiwi, 2014) have similarities with the researcher in terms of utilization of creative problem solving model while the difference was the output/product that be produced. Pratiwi (2014) used creative problem solving model as a model of mathematics learning that was applied in class to support student's interest and learning result while researcher use creative problem solving model as orientation of computer-based interactive instructional media development. As for the constraint of research that was conducted (Pratiwi, 2014) was in the learning activities, students were not yet confident when they asked and answered questions. Refers to the problems and related research results of GeoGebra and creative problem solving model that had been done before, it is necessary to do research about utilization of GeoGebra application in the development of computer-based interactive instructional media oriented creative problem solving model.

Based on the background of the above problem it is able to be formulated problem how is GeoGebra application utilization in the development of computer-based interactive instructional media oriented creative problem solving model the purpose of this development research is to describe the design of GeoGebra application utilization in the development of computer-based interactive instructional media oriented creative problem solving model.

MATERIALS AND METHODS

The type of this research is development research. The output be developed is GeoGebra application utilization in the development of computer-based interactive instructional media oriented creative problem solving model. This research uses 4-D research and development model. This 4-D research and development model was developed by Trianto and Pd (2007). As for the stages of the 4-D research and development model are: define, design, develop and disseminate but in this research only be limited to the design stage. Define stage (defining) is a previous stage of product development definition is in the form of computer-based interactive instructional media. This stage includes defining of necessity, curriculum, materials, literatures and individual students. The definition of necessity is done, so that, the problems which be confronted in the mathematics learning can be well understood. The definition of curriculum, materials, literatures are done to well understand the suitability and accuracy of the limitation on materials use in research based on basic competence that has been established by the educational unit. The student definition is done, so that, the adjustment of the ability level each individual student can be well identified, so that, the reference in designing the output can be seen clearly.

The design stage is the stage of computer-based interactive instructional media design preparation whose orientation is syntax of creative problem solving model. The creative problem solving model has four syntaxes those are problem understanding, planning, plan implementation and re-examination. The design of problem understanding syntax is designed to present a mathematics problem that enables students to explore in understanding the problem and the problems which are presented is the interaction between the established material learning and the relevant daily life. The design of the plan syntax is designed to construct thoughts and new knowledge of students in planning various possible solutions that can be used to solve the problem. The design of the plan implementation and re-examination syntax is designed to use when students choose one of the most appropriate solutions for a problem-solving, students can make a direct correction between the accuracy of the selected solution with the mathematical concepts is learned.

The location of this research is in STMIK-STIKOM Bali. The reason of this research was conducted at STMIK-STIKOM Bali because considering the result of previous observation those are tutorials and computer-based learning media were ever used had not been able to attract the interest learning of some students. These was because the instructional media that be used only help visualize and had not been able to involved students directly in simulation process of the instructional media. So, it is necessary to conduct research that be related to the computer-based interactive instructional media in this school of IT (Table 1).

Table 1: The stages implementation of research activities

Stages	Activities	Indicator
Defining	Defining of necessity	Students need visual aids in learning mathematical concepts
		Computer-based interactive instructional media that can be simulated directly by students is needed in the mathematics learning process
		The concept of learning-oriented students centre is needed, so that, students are able to build the new knowledge
	Defining of curriculum, materials, literatures	2013's curriculum is the curriculum applicable in the education unit of Indonesia today
		The suitability of learning materials which are presented must be relevant to the main competencies and basic competencies that were established by the education unit
		Textbooks, teacher books and student books must be relevant with applicable curriculum
	Defining of individual students	The student ability to solve math problems is high
		The student ability to solve math problems is moderate
		The student ability to solve math problems is low
Design	Design of problem understanding syntax	Presents the daily life problems that are relevant to the set material learning
		Motivate the students to explore in understanding well the problems that are presented
		Motivate students to be able to connect learning materials with the problem
	Design of the planning syntax	Present learning materials that enable students to be able to design solutions of problem solving
		Construct the student's new knowledge to find various forms of workable solutions for problem solving
		Encourage the students to choose one of the solutions that will be used as a problem-solving plan
	The design of the plan implementation and re-examination syntax	Presents a form of elaboration that allows students to solve problems according to the problem-solving plan
		Motivate students to re-examine the accuracy of solutions which be used as problem solving
		Motivate the students to understand the concept of learning materials in more depth

This development research uses qualitative data and quantitative data. Qualitative data that be used are data related the process in adjusting the definition stage and the design stage of computer-based interactive instructional media with the determination of provisions those are analysis description and planning description. Quantitative data in this research are data related to the identification level of each student's ability as a reference for designing output. Preliminary test conducted to determine the preliminary ability of each individual student in solving mathematical problems is an instrument of data collection in this research with data collection techniques in the form of test methods. The non-test method that be used is a requirement observation sheet. Qualitative descriptive data analysis technique is a technique of data analysis in this research. The implementation of each stage in this development research activities are presented on Table 1.

RESULTS AND DISCUSSION

The mathematic's principles and concepts which are commonly used repeatedly and as continuous of one material with another material and also the demands of a definite answer to the mathematics problem need a high degree of accuracy. Geometric understanding will also be expected to be embedded in the students themselves. The expectation will not be fulfilled if in the class room learning activities still only use the blackboard or just describe the monotonous geometry on the board. The main constraint is the limited time to exemplify varied forms of geometry and dictate one by one students in order to know the extent which ability to capture material that be learned. Innovation of mathematics learning that apply the utilization of computer application program will be very support in solve this problems.

Mathematics learning will be greatly helped by the various forms of computer application program utilization. Different types of computer application programs that can be utilized for mathematics learning had been increasingly emerging. One of them is GeoGebra that is a computer application program that can be utilized as a mathematical instructional media. GeoGebra complete features make it as a computer application program that can be precise and fast in creating geometry objects. Users will also be easier to use because of the forty language support owned GeoGebra, one of which is the Indonesian language. Mathematics instructional media that utilize GeoGebra application are not only be able to visualize learning materials but mathematics instructional media can be made as interactive as possible by using GeoGebra application. The point here is that students can be directly involved the use of media in simulating the learning materials that are presented by the media.

The GeoGebra application program supports almost all of topics in mathematics learning but in particular the application program is designed for mathematical learning on geometry and algebra materials simultaneously. According to Hohenwarter and Fuchs (Suprihady, 2015) GeoGebra is a multifunctional computer application program in mathematics learning for various levels of education that study mathematics. As for some utilization GeoGebra to support mathematics learning, GeoGebra can be used to model and describe mathematical principles and concepts, GeoGebra can help build the student's own thinking about characterizes of mathematical objects, GeoGebra can motivate students to find their own principles and concepts of mathematics. GeoGebra can be used as learning material. In this study, researcher use GeoGebra as a computer-based interactive instructional media on learning materials that are adapted to the basic competencies of the mathematics subject in the school of IT curriculum. This is because researcher conducted research in STMIK-STIKOM Bali.

Referring to research by Wihardjo *et al.* (2016) on the utilized of GeoGebra application which showed a significant difference in mathematical learning achievement among students who used GeoGebra application in mathematics learning with students who were without using GeoGebra application in mathematics learning. This was supported by the acquisition of learning achievement which be gotten by students who used GeoGebra applications in mathematics learning better than students who were without using GeoGebra application in mathematics learning, so, it was found an constraint in research that was conducted by Wihardjo *et al.* (2016) that is: there was not yet of motivation to utilize computer application program in learning activity especially the use of GeoGebra. Answering the constraints of research that was conducted by Wihardjo *et al.* (2016) then it is necessary to hold research on the use of GeoGebra applications in the instructional media development. This instructional media development must be adapted to the materials and literature which was set by the educational unit with the objectives of mathematics learning that was described in the curriculum development guidelines. Adjustment of instructional media development should also consider the level of student's mathematical ability because each individual student has different skills and thinking styles

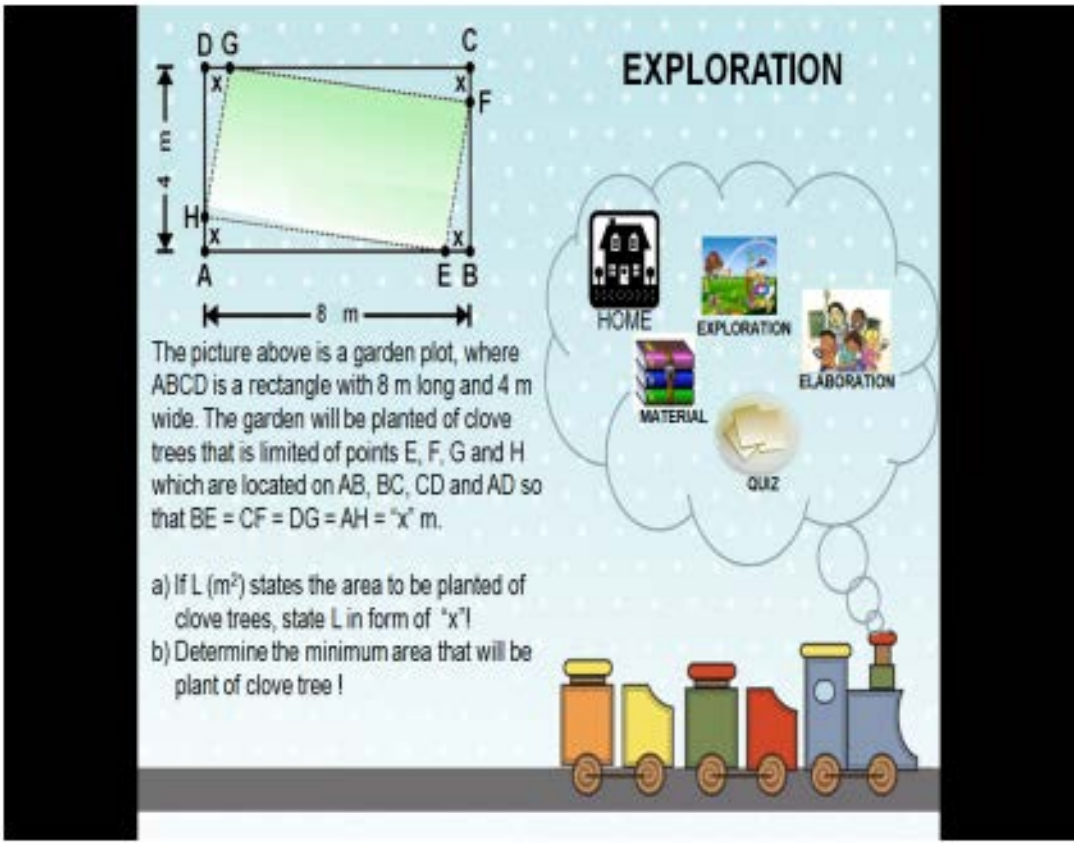

Fig. 1: Exploratory menu display

in building new knowledge. Student centered learning can be used as a reference to respond the differences in each of these students. These are in line with research that was conducted by Pratiwi (2014). Research by Pratiwi (2014) contained about the application of student centered learning that was creative problem solving learning model that affected the desire and achievement mathematical learning of students. However, students had not been confident when asked and answered the question in learning activities were becomes an constraint from research (Pratiwi, 2014). Research on GeoGebra application utilization in the development of computer-based interactive instructional media oriented creative problem solving model can be used as an alternative to respond the constraint from some previous research above. The design of computer-based interactive instructional media consists of 4 syntaxes (problem understanding, planning, plan implementation, re-examination) because it is oriented from syntax of creative problem solving model by Polya (Utomo, 2012).

The previous stage designing of computer-based interactive instructional media development oriented creative problem solving model that utilizes GeoGebra application program starts from the syntax of problem understanding. Selecting problem which is related to learning material and accordance in the context of daily life problem and then presenting this problem to the form of the exploratory menu display. The problems presenting in the exploratory menu display is intended to enable students explore all of their previous knowledge to investigate the intent of the issues presented, so that, students are able to well understand the problem and can determine the previous steps which they must do to find the correctness of the solution in solving a problem. Here's an exploratory menu display that presents a problem and comes with an figure illustration in the form of problem (Fig. 1).

In this menu display students presented a mathematical problem about the connection of geometric concept from previous material with the concept of quadratic function. Problems about a garden that requires

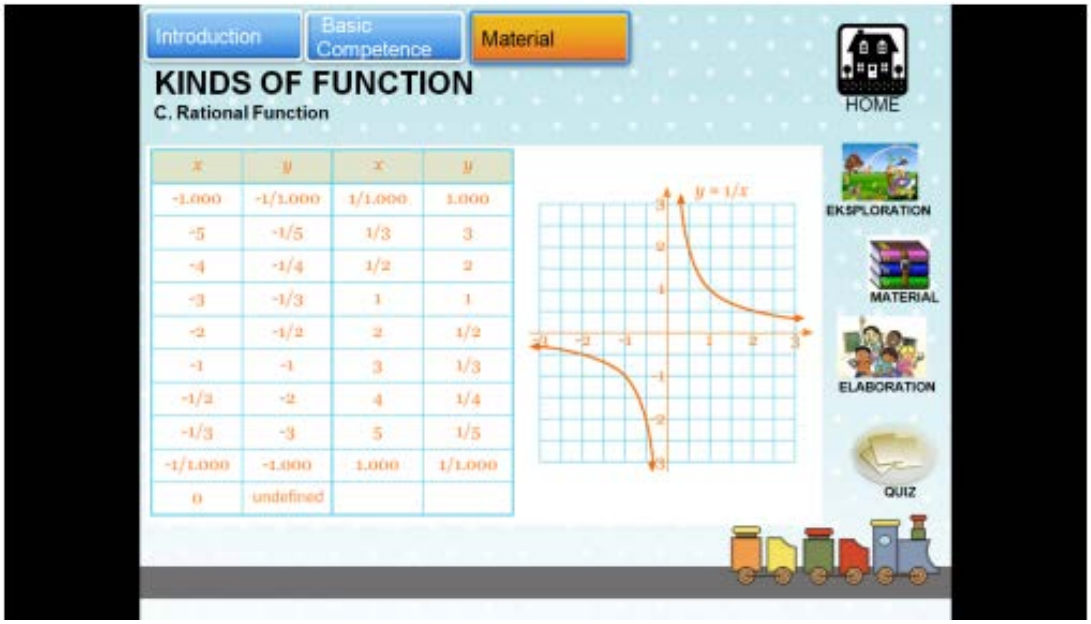

Fig. 2: Material menu display

students to declare the area that will be planted this clove tree into the form of "x" to make students think to understand the purpose of that problem. Students are invited explore to find a solution of a garden field problem that will be planted with clove trees on condition that there are limits at certain points. Students are encouraged to recall previous material about geometry. Students can find several shape of geometry such as, rectangle, parallelogram and some right triangles with the help of image in this exploratory menu display. It motivates students to discover new knowledge while combining several concepts of different types of geometry, so that, students can well understand that the purpose of problems which be presented is to find the area of the parallelogram is the area of the garden to be planted by the clove trees. When students are able to understand the purpose of the problem presented, it means that students should be aware of parallelogram area from subtracting the rectangular area by area of four triangular (Fig. 2).

On the planning syntax the students are presented some learning materials in accordance with basic competence of 3.5. It is explain and define functions (mainly linear functions, quadratic functions and rational functions) formally including notation, domain, range, symbolic expression and graphic sketches. The material that be presented will guide students to discover the linkage of the material with a combination of some geometry's concept that the students have understood on the exploration menu display. Here is one form of material menu display that presents the concept of rational function.

Students learn some material relevant to basic competence of 3.5 in this menu display. Students construct their new knowledge by analyzing the problem of planting clove trees on a plot of the garden and connecting it with learning material that be presented, so, that students can find various forms of solutions that can be used as solutions for problem solving. The interrelationship between some plane are previously analyzed on the problem understanding syntax with linear function, quadratic functions and rational functions material that students are learn on the material menu display can be used as a reference in developing problem-solving plans. Students can combine the form of a linear function to the length by one of the plane forms that is listed in the image of understanding the problem. When students determine the extent of the clove tree planting area that must apply multiplication operations then students find the form of quadratic function. The quadratic functions concept will be used to answer the first problem that is to express the area of clove planting in the form of "x". Problem solving for the second problem can immediately is found the solution by combining a parallelogram concept to the function concept. Students can also explore solutions in other ways, such as combining the function concept with the rectangular concept and some triangular then searched the reduction to find the area that will be planted of clove trees. Some other forms of solutions can also be found by students in accordance with the creativity that they have. When students have been confident of connecting the planes

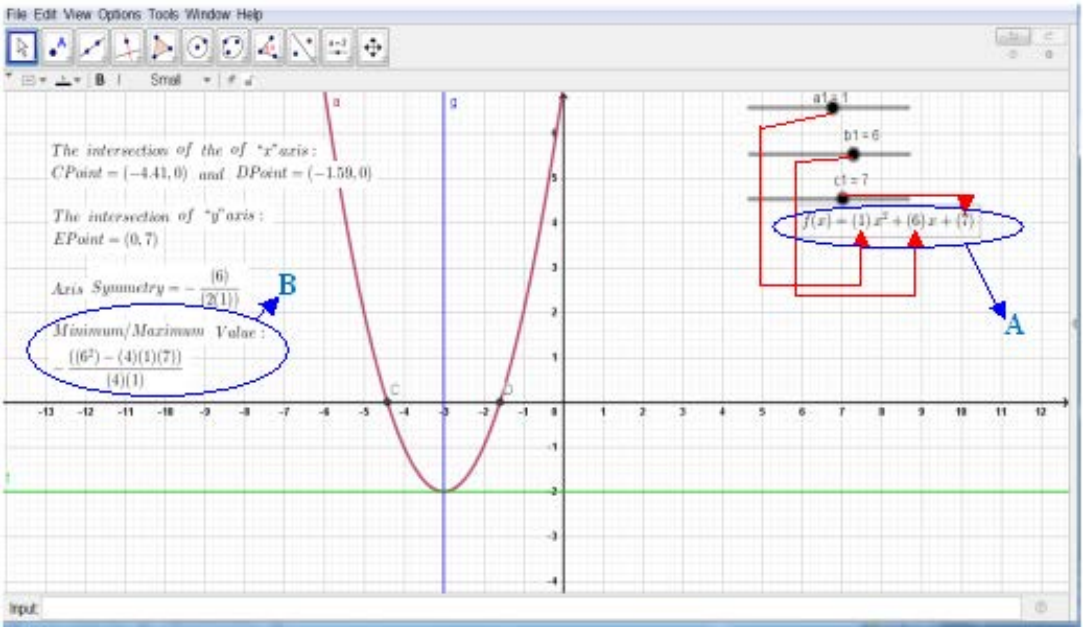

Fig. 3: Elaboration menu display

concept to a problem presented with one of the functional concepts then various alternatives that can be used as solutions to problem solving will emerge. One of these alternatives can be chosen by students to use in developing the problem-solving plan.

The syntax of the execution plan and re-examination is presented in the elaborate menu display. In this elaboration menu display the utilize of GeoGebra application program is really used to understand more deeply the concept of learning materials that are studied and do a re-examination of the solutions which are used to find answers of the problems are related to the concept of learning materials. In the elaboration menu there are three main menus those are elaboration menu for linear function, elaboration menu for quadratic function and elaboration menu for rational function. In the syntax of the execution plan and re-examination this will be discussed about one of the elaboration menu is the elaboration menu for the quadratic function considering its relating with quadratic function problem which is presented by the syntax of problem understanding. Here is one of elaboration menu display that presents the form of the concept in quadratic function (Fig. 3).

The arrangement of plans for solutions to problem solving previously formulated by students can be solved with the help of this elaboration menu. Suppose the student chooses one of several solutions that can be used as problem solving, for example, if the student uses the option of determining the reduction of rectangle with some triangles to find the answer for the parallelogram area. This means that students find the parallelogram area in the form of quadratic functions, furthermore to get answers to the minimum area of the parallelogram student can adjust the form of the quadratic function that is obtained to the form of quadratic functions that exist in this menu that is on the marked of "A" code. Adjustment of each coefficient of "x" and a constant can be adjusted by sliding the "a1", "b1" or "c1" sliders. In addition to finding the form of graphics, students can also find out the meaning for the concept of the parallelogram minimum area that is configured to form the quadratic function. This minimum area can be seen in the dialog box that is marked by "B". Students are directly involved in simulating of functional form by sliding the "a1", "b1" or "c1" sliders according to their needs, so, students will build their own knowledge of quadratic functions that have a minimum value when the graphic curve is facing upwards that is when the "a1" coefficient is positive and has a maximum value when the graphic curve faces downwards when the "a1" coefficient is negative.

Students will also build their own knowledge in understanding the changes that occur in the coefficients of "a1", "b1" or "c1" that it can affect the changes of the graph shape both on the parabolic chart and the symmetry axis graph. Changes in the shape of parabolic and symmetrical axes also affect the changes of numbers in the maximum/minimum value dialogue box the symmetry axis the intersection of the "y" axis and the intersection of

the "x" axis. The changes that occur in these numbers will lead student's thinking to get creative in finding their own concepts of quadratic functions. In the symmetry axis dialogue and the maximum/minimum value is intentionally made indirectly on the final answer, so that, students are able to find new concepts from the existing formulation. Students are required to understand that the coefficients and constants in the symbolic form of the quadratic function are related to the change in value of the symmetry axis and the maximum/minimum value. Similarly, the linkage between the "a1" coefficient with the direction of the parabola curve opening. When the "a1 = 0" is not a parabola formed but a straight line here students can associate the concept of liner function. When the "a1" coefficient is negative the parabolic curve will face downwards and conversely in which case the students construct a new concept to determine the maximum and minimum value of a quadratic function and the changes that are occurred at the point of intersection from the parabolic curve to the "x" axis. The change in the point of intersection from the parabolic curve to the "y" axis will also be affected by the change in the "a1" coefficient value. Students here will have their own creativity to understand well how and what is the linkage between the points of intersection of the parabolic curve to the "y" axis with the change of "a1" coefficient value.

The coefficient of "b1" is also related to the change in the sympatric axis value and the maximum/minimum value. In addition, the change in the "b1" coefficient will also affect the position of symmetry axis as well as the change in intersection of the parabolic curve to the "x" axis. Students will be encouraged to investigate the linkage and respond to changes that do not occur at the intersection point of the parabolic curve against the "y" axis. When students find the cause of a change that does not occur at the point of intersection of the parabolic curve against the "y" axis it means student has been able to construct a new concept of it. The "c1" coefficient will only be related to the changes that occur with the maximum/minimum value and the intersection point of parabolic curve against the "x" axis and the "y" axis. Students are required to construct a new concept of it with their own creativity. The blue line representing the symmetry axis and the green line representing the maximum/minimum value that will interest students to investigate what likes is that peak-point notation of the parabolic curve. It will motivate students to well understand that the peak of the parabolic curve is a combination of the symmetry axis value and the maximum/minimum value. All forms of linkage that is students learn here will construct theirs new knowledge. When students find problems that is related to the quadratic function concept then by using their own creativity they will find a unique solution as a choice to answers the question of that problem-solving.

In this elaboration menu, in addition to students can implement problem-solving plans that have been prepared previously, they can also conduct a re-examination of the selected solution in response to problem solving. When their answers a bit getting misses, the students will be able to understand what the cause and how is the step to overcome it. Students also get material deepening on this menu because when implementing a problem-solving plan and do a re-examination of the answer, students will automatically find new concepts that they construct from their own way of thinking. As with the previous peak-point formulas they think that they should memorize it to solve the problem of quadratic functions but by interacting in this menu, students well understand where it came from that formula. Students will be able to solve the problem of quadratic functions with new concepts which they find without having to memorize the formula. Students will understand what is axis of symmetry by forming a new concept that they find themselves. Based on some of the things that have been described previously then there are some things that researchers will discuss specifically about the results of this study includes the following.

Define stage: At the defining stage consists of necessity defining, defining of curriculum, materials and literature, individual student defining. The defining of necessity that is intended is to make adjustments of computer-based interactive instructional media which is designed with previous necessity. That previous necessity is accordance with the previous observation which indicates that the instructional media that can involve students in simulation directly and is supported by the concept of students centered learning will be needed to help students in learning mathematics objects that the nature is abstract, so that, students are able to creativity in construct new knowledge with their own thinking style. The definition of curriculum, materials and literature is to make adjustments of computer-based interactive instructional media that is designed with curriculum that be enforced by the educational unit. The suitability of learning materials that be presented in instructional media is also adapted to the textbooks, teacher books and student books that have been selected by the educational unit. This selected literature must

have considered its relevance to the educational goals listed of core competence and basic competence in a curriculum. Defining of individual student is to make adjustments to computer-based interactive instructional media that is designed with the diverse of student ability. Computer-based interactive instructional media is designed specifically for this instructional media can be applied by all students who have high, medium or low mathematical ability.

Design stage: At the design stage consists of four syntaxes those are problem understanding, planning, plan implementation and re-examination. In problem understanding syntax the instructional media is designed to present a previous problem which be related to daily life whose context is relevant to the set learning material. Instructional media is designed specifically to motivate students to explore of well understanding in mathematical problems and connecting those problems with mathematical concepts through their previous knowledge. In planning's syntax, the instructional media is designed to present learning materials that enable students to be able to construct their new knowledge to find various solutions that can be applied in problem solving. Those Various solutions can be selected one of which is considered the most appropriate to be used as a problem-solving plan. In the syntax of implementation plan and re-examine the instructional media is designed to present an elaboration form that enables students to solve the problem according to the problem-solving plan as well as to re-examine the accuracy of the solution that be used as the solution of problem solving. In this syntax students are also encouraged to understand the concept of learning materials in more depth.

CONCLUSION

Based on the results of previous research and discussion can be concluded that computer-based interactive instructional media is designed by utilizing GeoGebra application program and oriented creative problem solving model is designed specifically to encourage students to understand the concept of learning materials in more depth. The full features of the GeoGebra application program are utilized to design the instructional media which in its application can involve the student directly during the simulation process. This instructional media is supported by the concept of students centered learning that helps students in learning mathematics objects that the nature is abstract. This instructional media is designed specifically to be applied by students who have high, medium or low mathematical ability, so, that each individual student will be able to creativity in construct new knowledge with their own thinking style.

SUGGESTIONS

The suggestions that researchers provide in this research is the resulting instructional media needs to be done further testing of the students, so that, the understanding of the subject matter be given is more optimal. It needs follow-up by further researchers, so that, in the utilization of GeoGebra applications as instructional media can be designed with a more attractive design.

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