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Hawgent dynamic mathematic software as mathematics learning media for teaching quadratic functions

Tommy Tanu Wijaya[1, 4], Zhou Ying[1], Siti Chotimah[2], Martin Bernard[2], Zulfah[3] and Astuti[3]

[1]Department Mathematics and Statistics, Guangxi Normal University, China
[2]IKIP Siliwangi, Indonesia
[3]Pahlawan Tuanku Tambusai, Indonesia

[4]Email: tanuwijayat@gmail.com

Abstract. According to the observation of schools in Indonesia, the quadratic function graph is a lesson for junior high school students. For it is an abstract concept, students have difficulties to understand and picture out the graph functions. The main purpose of this research is to design a learning media to improve students' learning achievement by using hawgent dynamic mathematic software. The method of this research is research and development method. The target audience of this research were 32 students in experimental class and 32 students in controlled class. The result of this research is the material expert, research and media experts obtaining "valid" criteria. This means that the software is better than traditional teaching methods as students are able to easily visualise and generalise the graphical form of the quadratic equation. This automatically increases student's learning achievement and makes them find math interesting.

1. Introduction

Mathematics is a branch of science that is very important to be learned by everyone [1]. Mathematics is something concrete and can be proved. Basically, unwittingly mathematics learning is needed in everyday life to increase innovation and improvement in various aspects of life [2]. Therefore, Learning mathematics, should be directed to find out on how to help students have a deeper understanding of a concept. Based on fact of the 2013 curriculum aims to increase the high order thinking skills in order to adapt to the development of technology [3].

In general, students think that mathematics is a difficult, boring and scary subject. Especially when learning abstract materials, students are not able to focus on long lesson time [4]. These negative assumptions need to be eliminated and changed from the students' mindset about this negative assumption. Although these days learning mathematics has been using a conventional learning media, but the delivery to students is not optimal.

Therefore, it is necessary to study the appropriate media of mathematics in order to change the student's mindset [5]. The Selection of learning media should be according to the characteristics of the subjects and the purpose of learning. The accuracy in the selection of media affects the learning outcomes and the success of the students following the learning [6].

Computer technology is often used for educational purposes. But the use of interactive learning media such as mathematic dynamic software is still rarely used in developing countries. In teaching and

learning activities, computer technology can make it easier for students to find, understand and expand knowledge in learning mathematics [7].

The Ministry of National Education (MEB) shows that the reasons to use technology is teaching [8]: 1) are to increase the collaboration between schools, teachers and students by using technology devices; 2) to increase the quality of education that is supported by software; to improve the students ability in using technology devices; 3) using softwares to picture out graphs and presentation software.

Hawgent dynamic mathematic software is one of the dynamic mathematics learning media. Hawgent is a software that is published by Guangzhou Education Technology Co, that was created based on the characteristic of real mathematics and mathematics education. Designed to solve mathematical problems such as geometry, algebra and dynamic problems, hawgent do not only have a simple design and easy to use but also is able to design 3D pictures that will make mathematical problems easier to understand, more interesting and enjoyable. Hawgent is an open source that can be downloaded in http://www.hawgent.com. There is also a use forum and information about hawgent to share mathematical problems that can be solved using hawgent.

According to the school observation in Indonesia, The quadratic functions graph is a lesson for senior high school students. Considering this material is abstract, a media is needed to facilitate the students in understanding the proofing and application [9]. In this journal, we will explain the media that is used to learn quadratic function by using hawgent dynamic mathematic software that is can to help students to have a deeper understanding in learning the quadratic functions graph.

2. Method

This research will use the research and development method [10]. This method will come up with a certain learning media and test the effectiveness of the learning media. The development of the learning media using dynamic mathematic software will follow two main development research steps which are the preliminary study (preparation and development) and formative study (evaluation and revision). Below are the steps to develop Hawgent dynamic software as a learning media for this research. The steps are given in Figure 1.
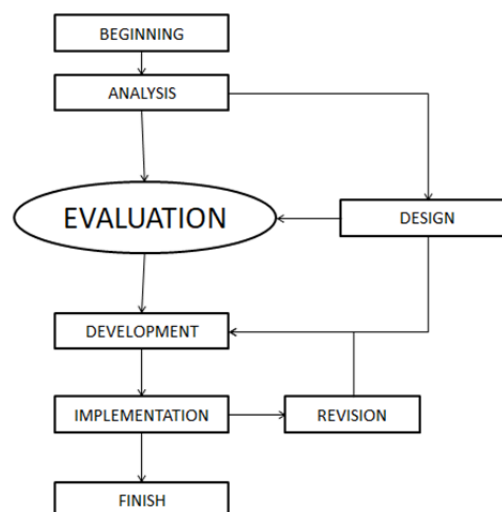
Figure 1. Steps to make the learning media using ADDIE model.

The technique of data analysis for this research is using the descriptive qualitative analysis which shows the progress of the product in the form of multimedia for learning mathematics on the topic of quadratic functions. The data collected from the try-out will be analyzed using descriptive qualitative statistics. The purpose of this analysis is to picture out the data's characteristic on each variable. The score analysis that uses likert scale and after the scores from the experts are calculated, we then categorise them according to the interpretation criteria by using the likert scale that can be seen in Table 1.

Table 1. Table validation criteria.

Score	Validity criteria	Description
$3.26 \leq x \leq 4.00$	Valid/very good	No revision
$2.51 \leq x \leq 3.26$	Valid enough	Need a little revision
$1.76 \leq x \leq 2.51$	Not very valid	Need a lot of revision
$1.00 \leq x \leq 1.76$	Not valid	Not to be used

3. Results and discussion

3.1. Observation

The first step in developing the hawgent software is analysing the problems faced by students on the topic of quadratic function. Before making the learning media, researches will interview the students on the pre-requirement topics related to the quadratic function topic that they need to know. The result of the interview can be seen in Table 2.

Table 2. Students' interview result.

No	Pre-requirement mastery	Number of students	Percentage
1	Understanding of common variable	11	34.38%
2	The order of operation	7	21.88%
3	Object position in the Cartesians plane	23	71.88%

Table 2 explains the students' interview result, there are 3 pre-requirement questions that were asked to the students. 23 students or 71.88% of the students were able to master placing object method on the Cartesians plane. While the other 6 out of 9 students who were not able to master the placing object method are still uncertain when identifying the x and y axes and the other 3 students are unable to understand the picture form of the Cartesians plane. These findings are taken into consideration when developing the learning media. In the other results, there are 21 students that are unable to understand the meaning or the basic concepts of the variable in a line equation when they are in the 7th grade. But 11 students or 34% of the students were able to master the topic. Only 2 out of 11 students were able to present them while the other 9 students followed the book procedure. There are 25 students that were unable to understand the order of operation such as commutative, associative, distribution, inverse and identity. As a result, students make mistakes when calculating and are confused on which one comes first. But, there are 7 students or 21.88% there were able to solve the problem even though they are unable to explain the process.

In Figure 2 (a), we can see that the student gave a statement of rules which determined the coefficient of x^2 and x as well as the constant values. But unfortunately the students did not explain the relationship between the coefficient and the constant with the result of the x and y value. However, the students did an experiment by putting the value of x, the end result is correct for every value of y but the students were unable to explain why is x=0. It is possible that students have studied intersection of straight-lines on the two axes but hesitate to give definite explanation. Another problem is that students experience errors when writing y symbol and instead wrote them as x. Actually, the students are trying to explain that the curve cuts the y-axis but there is an error in the distribution process on the factor of quadratic equation. Another problem is that the student did not revise the result and there is a difference between the data result and graph. The last problem is that students did not provide an explanation that is related to the results of both data and graph. In Figure 2 (b), we can see that the student is trying to make two

conditions that are to describe the variable and constant from the quadratic equation to find the maximal and minimum value and make experimental data using integers in sequence to create the quadratic equation curve. First-handedly, the student made data to place the point but there is a flaw in the student's calculation on x=2 and x=3 where the y value is supposed to be y=10 and y=24 accordingly. The student predicted that the next value of y will get bigger and faced with a difficulty to determine whether the graph for quadratic equation is going to curve upwards or downwards. After that, proceeding with the other alternatives by using the discrimination formula to find the maximum or minimum value but the student did not understand the purpose of the formula, so the result is not complete and done properly. We can see the difficulties faced by the students in solving the quadratic equation problems that can be seen in Table 3.

| (a) | (b) |
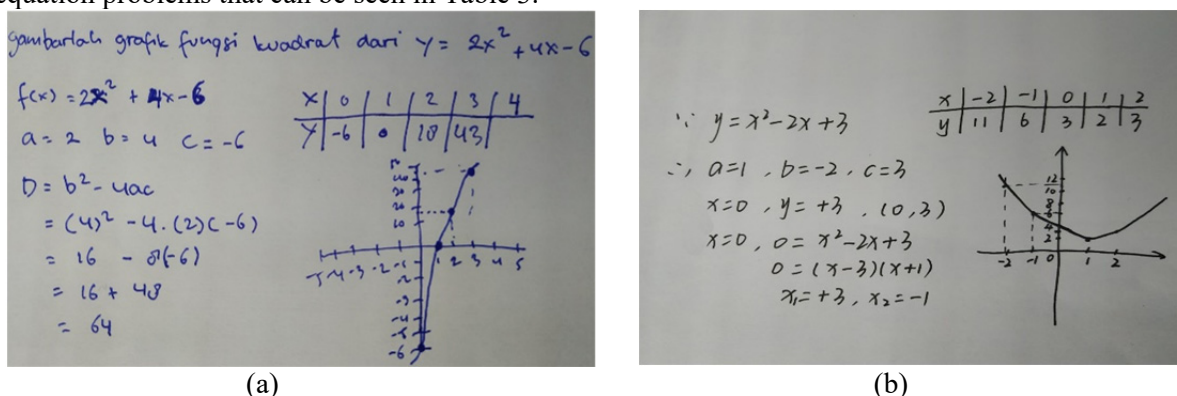
Figure 2. Students' work result (a) Making a graph from a given quadratic function equation; (b) Determining a value from a quadratic function equation.

Table 3. Students' ability in solving the pre-test problem.

No	Findings	Number of Students	Percentage
1	Understanding the meaning of function	14	43.75%
2	Explaining how to get the result	20	62.50%
3	Linking function and its graph	17	53.13%
4	Work process method	10	31.25%
5	Evaluate the proof of result	8	25.00%
6	Describing graph according to data	12	37.50%

In Table 2, we can see the difficulties faced by students when solving the quadratic equation that is related to the pre-requirement mastery topics, and these tend to be media material to handle students' difficulties. The main factors that needs to be considered when making this learning media is how students would be more active when using this software to prove the validity of the result as only 8 students or 25% of the students mastered the proving of results. Another factor that needs to be considered is the media should give the overview of the process from the meaning of the problem to the end result that is achieved as only 10 students or 31.25% are able to do it. The other factor is the media should be able to explain to the students on how to put in the right data that is related to the curve as only 12 students or 37.50 % of the students were able to do it. The media should also be able to identify the quadratic equation and the functions of coefficients and contents so that the students are able to solve the problem as only 14 students or 42.75% of the students were able to do it. Another factor is the media should be able to predict the quadratic function from the graph that is made so the students are able to solve the problem as only 17 students or 53.13% of the students were able to solve the problem. The last

factor that needs to be considered is that the media should be able to give explanation along with various solutions since only 20 students or 62.50% of the students were able to understand the problem.

3.2. Product design

In this step, a mathematic learning media is design for the topic of quadratic function graph using the hawgent dynamic mathematic software.

a)   Open hawgent dynamic mathematic software
b)   Click the button to show Cartesian coordinates on the screen
c)   Press the button to activate editing mode
d)   Press draw on the toolbar and then press normal curve y =f(x)
e)   Input the quadratic equation function in column f(x), fill the number of chart points needed to make the chart of quadratic equation clearer. After that click confirm.
f)   Create a slider for variables, a, b, and c, by clicking Structure on the toolbar and then click the Slider.
g)   To add color to the chart, click color, select the desired color, choose the option to color the chart, and graph contents, etc.
h)   Press the magnifying glass icon to enlarge the line on the chart
i)   Press this icon to minimize the line on the chart
j)   Disable the editing mode that is in step 3.
k)   Students can move the a, b and c slider to find the relationship of a, b and c on the graph.

An example is displayed following the steps above using the hawgent dynamic software is shown in Figure 3. The implementation of this material is done by the students themselves under the guidance of the teacher. After the students understood, the teacher gave few questions to improve the students' achievement ability, to ensure that the students understand the relationship of the constants A, B and C in the quadratic equation graph.
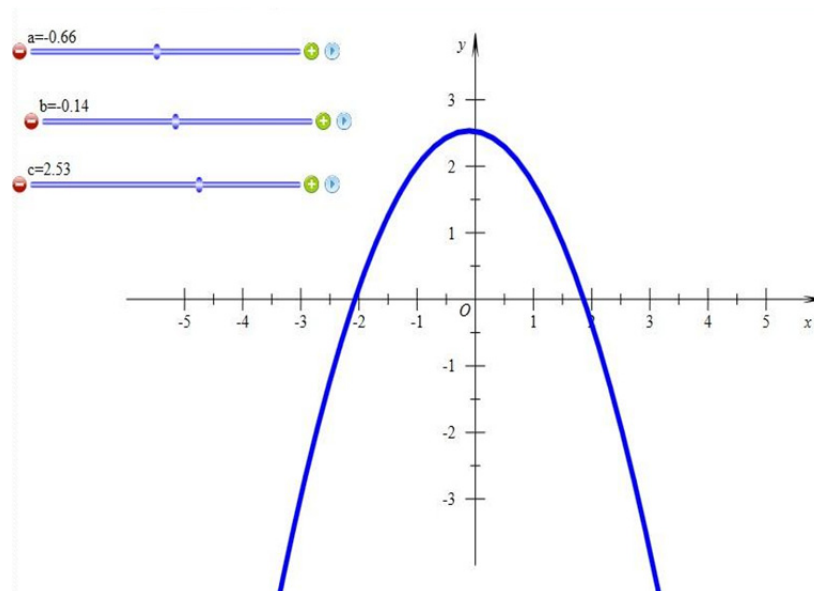
Figure 3. Image of Quadratic equation function.

3.3. Design validation

The validity of a learning media needs to be rated by media experts validators so that it can be implemented to the students. These validators included media experts who are lecturers that specialize mathematical software used as a learning media in junior high school and material experts who are lecturers that teaches and specialize in topics for junior high school and high school students.

Table 4. The validation of hawgent dynamic mathematic software.

No	Media expert	score	feedback
1	Graphing steps	3.00	Valid/ Little revision
2	Function equation with graph	2.90	Valid/ Little revision
3	Illustration on how to save media	3.25	Valid/ Little revision
4	Algorithm mathematical function's relation with graph	3.20	Valid/ Little revision
No	Material expert	score	feedback
1	Effectiveness on the media delivery	3.10	Valid/ Little revision
2	Compatibility with material	3.30	Valid/ No need revision
3	Creating alternatives in solving problems	3.28	Valid/ No need revision

Table 4 explains the validators' rating from media and material experts that needs to be developed to adopt to the junior highs school students' learning interest. According to the rating from the media expert, the media can be used but there is a need of revision in the general elements of formation of the media. While from the material experts, the media effectiveness need to be improved to help students in problem solving.

Table 5. Suggestions from media and material experts.

Response	Suggestion
Media experts	1. Make a graph that is simple but interesting
	2. Graph should be meaningful
Material experts	1. There is a need for guidance when doing the process
	2. Bring up the process of mathematical thinking ability
	3. Explaining basic knowledge first.

Table 5 explains the suggestions that are given by the media and material experts as an evaluation material. These suggestions serve as a reference to improve the learning media.

3.4. Product test
After the media is revised, the media is now implemented to the students for them to use based on the quadratic functions that will be solved by using hawgent software. With the use of this media, the students are more active, explore more to find the answer, there are interactions between the students in the form of questions or answers and the answers they give are more satisfying.

Table 6 explains that there is a significant increase in the students' ability in answering problems about quadratic equation after using hawgent software.

Table 6. Students' ability in answering the post-test problem.

No	Findings	Number of Students	Percentage
1	Understanding the meaning of function	26	81.25%
2	Explaining how to get the result	28	87.50%
3	Linking function and its graph	24	75.00%
4	Work process method	26	81.25%
5	Evaluate the proof of result	29	90.63%
6	Describing graph according to data	30	93.75%

3.5. Media evaluation

After the product test is done, the product is said to be interesting, so a product re-test is not needed. The hawgent dynamic mathematic software for the topic of quadratic function can be use as a learning source, a solution to boost the students' learning outcome and the students' interest to follow the teaching and learning process.

Some research that have been done about technology base learning media shows that students' are able to think, explore, develop an interest to study, elaborate the initiative to study, enthusiasm and creativity in the learning process [11-14]. The use of realistic mathematic approach that was done by Septika which give a result that this can boost the students' mathematics learning outcome [15].

In general, the advantage of the developed hawgent dynamic mathematic software are the media display is simple but catchy, It is easy for students and teachers to use, and learning quadratic function graph by using hawgent allows the students to obtain an interesting learning experience as they are more interactive. On the other side, this media also has its drawbacks which are the materials that are given were more to increase the students' understanding and this media is still not bilingual as a whole or most of them are still written in Chinese.

4. Conclusions

Based on the result and discussion of the research, the use of hawgent dynamic mathematic software as a learning media for the topic of quadratic function. The media is valid to be used in class based on the rating from the validators of media and material experts, to both field practitioners and students. The software is better than traditional teaching method as students can easily visualise the graphical form of the quadratic equation and they would be able to generalise. This automatically increases the student's learning achievement and enables math to be a more exciting subject.

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