Development of pool garden learning media on the topic of the derivative of polynomial functions for class XI students

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Abstract. One of the factors that determine the success of learning is the existence of appropriate learning media. The topic of the derivation of polynomial functions is one of the topics in mathematics that is considered difficult by students. So that on this topic, the creativity of teachers is needed in making learning media. This study aims to develop learning media for polynomial function derivative materials in the form of realistic visual media to instill the concept of polynomial function derivatives, which are named ‘Pool Garden’. This research is a development research that consists of three stages, namely the analysis of products developed, developing initial products, and product trials. The subjects of this study were 30 students of class XI Social Science, Batu City Madrasah Aliyah. The expert test results obtained a validity score of 3.45 which means that the learning media are valid and ready to be tested on a large scale. After a large-scale trial the student questionnaire results were obtained with an average value of 3.59, which means that practical and effective learning media are used in learning. Learning media has also been shown to increase student motivation in learning the concept of derived polynomial functions.

1. Introduction

Based on the 2013 curriculum revised in 2017 [1], the polynomial function derivative is one of the algebraic function derivative sub-material given in class XI of a Madrasah Aliyah (Islamic Senior High School) level in compulsory mathematics subjects. According to Rokhman [2], derivative material is one of the materials that presents a lot of deep and abstract concepts. According to most students of class XI Social Science 1 Batu City Madrasah Aliyah, this learning material is considered as a collection of abstract formulas and difficult to understand because of its abstractness. Whereas based on interviews of Compulsory Mathematics subject teacher of class XI Batu City Madrasah Aliyah, the teacher has been teaching the concept of polynomial function derivative by giving lecture and tended to directly provide the polynomial function derivative formulas. This might result in the less meaningful learning process because it only relied on memorization. In addition, this also resulted in a lack of students’ learning motivation because of the monotonous learning methods and did not actively involve students in the classroom [3].

One of the efforts that the teacher can do to overcome the problem above is to concretize the learning material to make it easier for students, for example, by using a learning media. According to Heinich [4], learning media that contain concrete experiences can help students in developing experiences and facilitate abstract concepts learning. This is in line with [5] that stated that mathematics learning media.
was a tool for students to deliver mathematical concepts into real forms with basic forms to understand the usefulness of mathematics, which was not merely a concept memorization. With this learning media, students are expected to be able to understand abstract concepts, especially in Mathematics, by using media or real activities in the learning process.

The individual characteristics of students need to be known in the learning design [6]. According to Fadillah [7], interesting and effective learning media can be used by teachers as one of the ways to improve students' learning motivation. Putri et al. [8] said that learning media was important in mathematics learning because it could improve students' spatial abilities and motivation. Furthermore, she said that there were positive responses from students in mathematics learning. The use of media in a learning process also results in new desires and interests, increases motivation and stimulation of learning activities, and even psychologically influences students [9]. Increased self-confidence of children is very important for their math development [10]. The media can also be considered as an alternative in the learning process that is needed to improve students’ motivation [11]. So that the use of learning media is expected to be able to make students more interested and motivated in the learning process, including the learning of polynomial functions material.

Manipulative learning media are valuable tools in teaching mathematics [12] and also has several benefits for learning mathematics, as stated by Heinich [4]. The benefits are as follows: the learning process will attract more attention of students so that it can foster motivation to learn; learning methods will be more varied, not limited only to verbal communication by the teacher. With learning media, students are expected not getting bored and the teacher is not run out of energy; if the teacher has to teach for every class hour, then the meaning of the learning material will be clearer so that it can be better understood by students. Students not only listening to the teacher's description, but also other activities such as observing, doing, demonstrating, and other things with manipulative media tools. Physically active lessons can be beneficial for learning mathematics [13].

There are various forms of learning media that can be developed such as visual media. It is a learning media that relies on the senses of vision such as photos, illustrations, flashcards, selected images, pieces of pictures, paintings, film frames, film series, OHP, graphics, charts, diagrams, posters, maps, etc. [4]. According to Raiyn [14], the use of visual learning media can assist in understanding most of the information and can help uncover relationships and patterns. This type of learning can also help students to develop visual thinking so that students can do better in understanding and storing information by associating ideas, words and concepts with images [14]. Visual learning media can also attract students' interest because it can affect students’ emotions [15]. Meanwhile, according to Lucas [16], realistic visual media usually contains more information than abstract visual media. So, the use of realistic problems in learning media will be able to explain mathematical concepts further. With the help of realistic visual media, it is hoped that it can help students understand the concept of polynomial function derivatives more clearly and concretely and it can improve students’ motivation with its attractive display and stories that may be presented in the learning media.

Based on the background described above, it is necessary to develop a learning media called "Taman Kotupol" (Polynomial Derivative Pool Garden) in the form of realistic visual media to facilitate students in finding the derivative formulas of polynomial function in the form of \( f(x) = ax^n \) that is able to improve students' motivation in learning mathematics material, especially polynomial function derivative learning material.

2. Methods
This research is categorized as a development research. The learning media "Taman Kotupol" (polynomial derivative pool garden) in this research was developed using the Borg and Gall development steps adapted from [17] which consisted of three stages of development including analysis of the product being developed, developing initial product, and product testing.

Analysis of the product being developed is started with the determination of the learning material and the learning media that is suitable with the learning material. Then determination of the learning media design by considering several things such as the purpose of using the media (to be able to
understand the polynomial function derivative learning material), target students, durability (related to the selection of materials and tools used), and the usefulness of learning media.

Product testing in this research consisted of expert validation and revision as well as large-scale testing and product revision. Expert validation consisted of media validation and material validation carried out with the help of three validators, namely a master lecturer of Mathematics Education that holds a doctor’s degree, a master student of Mathematics Education, and a teacher of Mathematics Subject. Large-scale testing in this research was conducted on students of class XI Social Science Batu City Madrasah Aliyah. This testing was conducted in the even semester of the 2019/2020 school year.

The data obtained from this research were expert validation result and students’ questionnaires related to the learning media "Taman Kotupol". The data were then analyzed quantitatively and qualitatively. Quantitative data in the form of expert validation result had been analyzed to determine validity of the learning media before it was applied and to determine the practicality of the learning media when being applied. Meanwhile, the students’ questionnaires result was analyzed as qualitative data to observe the effect of the learning media application on students’ learning motivation.

3. Results And Discussion
The result of research and discussion will be elaborated based on development steps according to [17] that have been determined previously, which includes the analysis of product being developed, developing initial product, and product testing. In product analysis, several things were carried out, namely learning material analysis, media design determination, and then the collection of learning material, tools and materials needed. The selected material was about polynomial function derivative, sub algebraic function derivative sub-material in compulsory mathematics subject of class XI in the 2013 curriculum revised in 2017. The researchers created the learning media design and generated Student Activity Sheets (SAS) for helping the students in learning activities as a guidance on what to do and for helping the teachers themselves guiding the students efficiently during the learning process. Then the determination of the materials and tools needed to create the designed learning media.

The form of the media was referred to one form of visual learning media according to [4], which was in the form of three-dimensional paintings. The approach used in developing the learning media was a realistic approach. This realistic approach was selected because of the result of previous researches that suggested the use of realistic mathematical approaches that could improve students' problem-solving ability and independence [18]. According to [8], realistic approach can also improve students' spatial ability and motivation. Therefore, this learning media is referred to as realistic visual learning media.

A realistic approach was applied in the design of the learning media by using a background picture of a pool garden ecosystem that was well known in the daily lives of students. The learning media was designed to illustrate a pool garden ecosystem with numbered stairs and trees with amoeba attached on it. Therefore, the name of this learning media is "Taman Kotupol" (Polynomial Derivative Pool Garden). The media was mainly made of plywood boards with blue flannel cloth base and wooden frames. The front side contained stairs numbered from 1 to 5 (made of zinc plates), trees (made of recycled paper wrapped in plastic vines), animated pool water (made of flannelette), amoeba (movable eyed and magnetized pompom) and the name of the learning media (block letters shaped flannelette) arranged in such a way as to describe the pool garden ecosystem. While the back side of the board contained instruction for using the media. For more details, the front and back side of the learning media design is presented in Figure 1 and Figure 2.
Figure 1. Design of the front-side of the learning media

Figure 2. Design of the backside of the learning media

Student Activity Sheets (SAS) can be used as a source of material that can help students to learn independently so that the students do not depend on the presence of teacher(s) in class [19]. The SAS contains the purpose of the activity, the steps to do, the amoeba life story in the pool garden ecosystem, instructions for using the media, examples of questions and simple questions that had been solved using the learning media, development questions, and conclusion. The purpose of the activity is to determine the derivative of function \( f(x) = ax^n \). The steps that must be taken by the students are as follows: understand the story of amoeba reproduction; pay attention to example of problem and how to solve it using the media "Taman Kotupol"; work on simple questions; make other problems/questions and solve them; and make a conclusion about the formula to determine the derivative of the function \( f(x) = ax^n \).

After the initial product in the form of learning media "Taman Kotupol" and SAS had been developed, then a product testing was conducted. The testing was expert testing and product testing. Expert testing was conducted to determine the validity, practicality, and effectiveness of the learning media. The average score of each aspect of learning media was obtained from the validation of 3 experts consisting of 1 lecturer in Mathematics Education at Universitas Negeri Malang, 1 teacher of
Mathematics subject of Mamba'ul Huda Madrasah Aliyah and 1 master student of Mathematics Education at Universitas Negeri Malang. The average score is presented in the Table 1.

**Table 1. Media validation results**

| No. | Aspect | Average Score of Each Aspect |
|-----|--------|------------------------------|
| I  | Content of Learning Media | | |
| 1  | The Media can help students to learn mathematics | 3.33 |
| 2  | The Media can help students to build understanding of mathematics | 3.67 |
| 3  | Activities provided enable positive interaction between students and learning media. | 3.33 |
| 4  | Activities contained in the learning media usage are in accordance with the learning objectives | 3.67 |
| 5  | Learning media do not cause ambiguity | 3 |
| II | The Use of Learning Media | | |
| 1  | Can be used to assist students in achieving learning goals | 3 |
| 2  | Can be used as a support for learning mathematics in school | 3.67 |
| 3  | Can encourage students to be more active | 3.67 |
| III | Form and Display (Manipulative / Physical Media) | | |
| 1  | Attractive learning media display | 4 |
| 2  | In proportional form | 3.3 |
| 3  | Contextual media | 3.3 |

**Validity Score**: 3.45

Based on the expert testing result above, the validity score of the learning media "Taman Kotupol" was 3.45. It can be concluded that the learning media was valid and ready to be tested on a large scale. The expert validators suggested several item for the improvement of learning media as follows: stairs and numbers needed to be made larger to make them easier to see; the size of the amoeba needed to be made a little bit smaller; and the board needed to be made of iron or zinc plate on the entire surface so that the amoeba did not fall when being moved.

The next testing was conducted to test the practicality and effectiveness of the learning media by analyzing students’ responses through the questionnaires. The questionnaires were given after finishing the learning activities. Learning in the classroom with the help of manipulative media is carried out in groups, with the hope that students can construct the mathematical concepts being learned. Important peer contributions to mathematical exploration during learning [20]. The result of the students’ questionnaires is presented in the Table 2.

**Table 2. Student questionnaire results**

| No. | Aspect | Average Score of Each Aspect |
|-----|--------|------------------------------|
| I   | Presentation of material | | |
| 1   | The mathematics learning media is easy to be used | 3.89 |
| 2   | Problem presentation in the mathematics learning media helps me understand mathematical concepts | 3.70 |
| 3   | I enjoy learning mathematics through this learning media because it is interesting | 3.81 |
| 4   | This learning media makes me love mathematics | 3.11 |
| 5   | This learning media makes me want to understand mathematics even further | 3.07 |
| II  | Language and display | | |
| 1   | The instruction and information presented are easy to understand | 3.63 |
The learning media display is attractive 3.93

Practicality and Effectiveness Score 3.59

Based on the table above, the practicality and effectiveness score is 3.59. This shows that the learning media was practical and effective to be used in the learning process. The testing result of this learning media product also showed that the use of the media in learning process resulted in new desires and interests, increased motivation and stimulation of learning activities, and even affected the students psychologically, that was in line with the statement of [9]. This is also in line with the result of research by Capuno et.el. [21] which said that through the use of media, students were involved in it, the media helped students in knowledge retention, and the use of media could motivate students.

In addition, it can be said that the problem presentation in the mathematics learning media helps students in understanding mathematical concepts. This is in accordance with the research result conducted by [22] which stated that the use of semi-concrete learning media was expected to be able to improve students’ cognitive abilities. The results of this study are also in line with Carbonneau [23] which states that using concrete media can improve math skills. Concrete experiences or activities are also valuable education for students [24]. Based on the product testing result, it can also be concluded that the developed learning media is quite attractive. Because of this attractive nature, learning media "Taman Kotupol" is also expected to be able to provide positive feedback on the learning process, and this is in line with the research result of [25].

4. Conclusion

Based on the expert testing result conducted on "Taman Kotupol" (Polynomial Derivative Pool Garden) learning media, validity score of 3.45 was obtained. This meant that the learning media was valid and ready to be tested on a large scale. Based on the results of student questionnaires, an average practicality and effectiveness value of 3.59 was obtained. This showed that the learning media was practical and effective to be used in a learning process and was proven to be able to improve students’ learning motivation in learning the polynomial function derivative learning material. This learning media is expected to be able to benefit teachers, students, schools and especially researchers. This learning media is still limited to polynomial function derivative learning material with positive integer coefficients. Therefore, it is hoped that further researchers can develop this learning media for other broader mathematical materials.

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