Developing A Media ‘Visual Design of Pop Up Mathematics Book’ as a Supporting Tool in Inquiry-Based Learning for Learning Three-Dimensional Figures

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Abstract. Inquiry-based learning is one of the learning models that involves more students with the invention of concepts or formulas as its main goal. Inquiry learning can improve the students’ learning outcomes and learning quality. Inquiry learning steps include investigating problems, formulating hypotheses, designing experiments, analyzing data, and concluding. The main problem faced by the students when dealing with inquiry learning is to formulate the hypotheses and find the formulas. The objective of this research is to develop a media called Visual Design of Pop Up Mathematics Book to overcome the difficulty of inquiry learning on three-dimensional figures. This research is a media development research which is effective to support inquiry-based learning. The development processes carried out by the researcher through the selected development model include product analysis, the first product development, expert validation and revision, small-scale field test and product revision, large-scale field test and the final product. Subjects were 8th grade students of a state secondary school in Wonogiri district. Based on the small-scale test, students who were given the media of visual design of pop up mathematics book obtained better results. They were more able to guess the possible steps and find the right way or formula in solving the problem than the students who did not use the media.

1. Introduction

Geometry is an important branch of mathematics and has been identified as a basic mathematical skill [1]. Geometry is important for students as it is also applied in other branches of mathematics. For example, geometry is applied in other subjects such as engineering drawings, drawing geometry, and so on. Basically, there are two objectives of learning geometry, namely to develop the logic of thinking skills and to develop spatial intuition referring to how someone views the space and area in the real world [2, 3]. However, there are some difficulties encountered in studying geometry especially in three-dimensional figures, which include the lack of students’ evidence, background knowledge, reasoning skills in geometry, geometric language understanding, visualization skills, teaching methods, unavailability of teaching materials, gender differences, and etc [4].

To prepare the learners who are able to face the education problem of 21st century, one of the learning models supporting the education has been modeled. It is the model of inquiry-based learning.
To improve the process quality and the learning outcomes, some experts have suggested the use of structured inquiry learning paradigms for teaching and learning activities in the classroom [5]. Inquiry can also increase student involvement in the learning process [6]. Inquiry is the process of defining and investigating problems, formulating hypotheses, designing experiments, finding data, and describing the conclusions of those problems [7].

The major obstacle in inquiry learning is solving problems based on investigations and assumptions made by the students [8]. Then, the need for the existence of a technology-based learning is needed to face the education of the 21st century [9]. Therefore, the development of a teaching material in the form of technology-based media is appropriate in the current learning process. The use of learning media enables the teachers to explain, describe, distribute, and deliver lectures more easily and effectively than depending only on words [10].

In an effort to overcome the problems in inquiry-based learning on the study of three dimensional figures and to answer the challenges of 21st century education, it is offered a media called a Visual Design of Pop Up Mathematics Book. The pop up book can help students in learning geometry, particularly on the solid figures [11]. The book combined with ICT (Information and Communication technology) provides a good understanding in learning [12]. Thus, a visual design of pop up mathematics book is made with the hope that students are able to construct the concept of three-dimensional figures independently and improve the quality of their learning.

2. Method
This research is a development research which is a method to produce a certain product [13]. The product made is in the form of a media, visual design of pop up mathematics book. The procedures in this development conform to Borg and Gall that have been simplified. The procedures include conducting: product analysis to be developed, the first product development, expert validation and revision, small-scale field test and product revision, large-scale field test and the final product. Data collecting techniques used were question and questionnaire. The subjects of this study were two students of 8th grade of SMP Negeri 2 Wonogiri (public school). Both students were the subjects for small-scale test in an effort to know the effectiveness of visual design of pop up mathematics book. Of the subjects, one student conducted a learning and worked on media-aided question while the other student did not use the media or just used a regular handbook. The students’ acknowledgment can be seen in table 1 below.

| Name                        | The use of ‘Visual Design of Pop Up Mathematics Book’ | Test |
|-----------------------------|------------------------------------------------------|------|
| Student A (Lathifah Ninda Prilia) | Not using the media                                | Yes  |
| Student B (Renata Amara Ginesti) | Using the media                                     | Yes  |

After the test, students then filled out a questionnaire of response towards the learning using the Visual Design Pop-Up Book of Mathematics.

3. Results and Discussion
3.1. Product Analysis
This activity was carried out with literature review and field study on junior high school students in Wonogiri regency who have used the latest curriculum. The literature review is related to the importance of learning geometry, especially the material on the solid figures [1,2,3]; the difficulties in learning geometry especially the material on the solid figures [4]; the inquiry learning model which is seen as an appropriate learning model according to some experts [5]; the difficulties in running the inquiry learning model [7]; 21st century learning that puts technology ahead [9]; the need to develop a media that can be applied to the learning process [10]; and the effectiveness of the existing pop up book [11,12]. Meanwhile, the field study related to the selection of the selected research sites based
on the average score of the national school exams representing the medium-categorized school i.e. SMP Negeri 2 Wonogiri.

3.2. First Product Development
The product, a visual design of pop up mathematics book, is a combination form of media as well as teaching materials, especially on the solid figures. This media were created to support the inquiry learning model to overcome the existing difficulties. The beginning pages consist of the cover, the instructions of media usage, and the competencies to be achieved. Figure 1 shows the front page that contains a cover with the title while Figure 2 is about the media usage instruction and explanation of the navigation buttons. Figure 3 contains geometrical material that is adapted to inductive reasoning for students to support learning, and Figure 4 is the image of all solid figures to be used in the media of visual design of pop up mathematics book. The display of the product made are as follows.

**Figure 1.** The front page that contains a cover with the title

**Figure 2.** The media usage instruction and explanation of the navigation buttons

**Figure 3.** Geometrical material that is adapted to inductive reasoning for students to support inquiry learning

**Figure 4.** The image of all solid figures to be used in the media

3.3 Small Scale Test
In this small-scale test, the subjects are in accordance with table 1.1 mentioned above. To know the effectiveness of visual design of pop up mathematics book, two things were done to measure it. First, the student using the media and the other without media were given a similar test, the same time, and the initial ability assumption. Second, the students’ response to the media used were taken. After a small-scale test, the results were different from the students before conducting the test. The use of visual design of pop up mathematics book influences the development of students' inductive reasoning, which can support inquiry learning.

3.3.1. A test to measure learning ability.
Both students were given some questions to determine whether there is a difference between student A and Student B after learning with different learning media. The question to solve is shown in Figure 5 below.

![Problem: A cube has sides (S) with the length of 20 cm. There is a shaded shape inside in which the height is the intersection of each space diagonal to the base center. Determine the volume of the shaded shape!](image)

**Figure 5.** Problem to measure the volume of shaded shape

The problem has a single answer, but the result from students have several steps. It can be seen below.

![The Results of Student A (without the media)](image)

![The Result of Student B (with the media)](image)

**Figure 6.** The result of the students
Based on the results of the two students above, it can be seen the differences as described in table 2 below:

**Table 2. The differences between two students abilities**

| Working Indicators                  | Student A                          | Student B                                                  |
|-------------------------------------|------------------------------------|-----------------------------------------------------------|
| 1. Ability to estimate before answering questions | Student A estimated to: - find the base area - find the volume of pyramid | Student B estimated using formula I to: - find the volume of cube - find the volume of pyramid with a formula (1/6 x the volume of the cube) Student B estimated using the formula II to: - find the height of pyramid - find the base area - find the volume of pyramid |
| 2. Ability to correlate to the previous materials | Not able to correlate the volume of pyramid with the volume of cube yet | Able to correlate the volume of pyramid with the volume of cube seen in the estimation using formula I |
| 3. Ability to solve the problem     | Able to answer the question correctly but not yet able to explore the other steps. | Able to answer the question correctly and able to provide other steps with the same final results. |

Table 2 on the difference of the results of the two students who received different treatments shows that the student who learned using the visual design of pop up mathematics book was more able to explore the estimation in determining the steps to solve the problem. Meanwhile, the student who learned without any media or just with a handbook was able to answer the question but had not been able to explore more deeply the other steps in solving the problem in Figure 4. Thus, it can be said that the use of visual design of pop up mathematics book is more effective in supporting the inquiry learning in terms of students’ ability to find estimation and relate it to the previous materials.

### 3.3.2. Student’s response to media.

From questionnaires given to students related to the media, an assessment was obtained as seen in the table 1.3 below: (with category 1%-25%: Very Bad ; 26%-50%: Bad ; 51%-75%: Good ; 76%-100%: Very good).

**Table 3. Student response to the use of media**

| Statements         | Score | Total | %    | Category   |
|--------------------|-------|-------|------|------------|
| Response to use the media | 100   | 125   | 80%  | Very good  |

From the student’ assessment which showed “very good” judgment can be interpreted that the media is appropriate and effective to use.
4. Conclusion

Based on the research conducted, it shows that the difficulty of inquiry-based learning can be minimized by using a media, Visual Design of Pop Up Mathematics Book, especially on the material of the solid figures (three-dimension). The success is measured through two indicators of the effectiveness of the media, namely question and students’ response questionnaire. The student who used the media obtained more learning experience than the student who did not use any media. Student B’s ability to estimate and to explore was better than Student A’s. Thus, it can be concluded that the media, Visual Design of Pop Up Mathematics Book, is more effective than the previous ones applied in the school. This is also the case with other studies, that the Pop Up Book that is visually designed is considered effective to use in today’s learning [12], and it is very appropriate to overcome learning problems especially on three-dimensional figures [11].

5. References

[1] Abdulah A H 2012 The Effects of Van Hiele’s Phases of Learning Geometry on Students’ Degree of Acquisition of Van Hiele’s level (Malaysia: Procedia-Social and Behavioral Sciences) p 251-266
[2] Sherard W H 1981 Why is Geometry a Basic Skill? Mathematics Teacher 74(1), 19-21
[3] Hong L T 2005 Van Hiele Levels and Achievement in Writing Geometry Proofs Among Form 6 Students (Kuala Lumpur: Universiti of Malaya)
[4] Fabiyi T 2017 Geometry Concepts in Mathematics Perceived Difficult To Learn By Senior Secondary School in Ekiti State, Nigeria Journal of Research & Method in Education 7(1) pp 83-90
[5] Paivio A 2013 Imagery and verbal processes (Ontario: Psychology Press)
[6] Artigue M and Blomhøj M 2013 Conceptualising inquiry based education in mathematics (Prancis: Springer)
[7] Andrew S 2015 Guided science inquiry instruction with students with special education needs (America: National Center for Research on Rural Education)
[8] Fielding M 2012 Beyond student voice: Patterns of partnership and the demands of deep democracy (London: Revista de Educación)
[9] Anna H Lint 2013 E-Learning Student Perceptions on Scholarly Persistence in the 21st Century with Social Media in Higher Education (USA: Scientific Research Publishing)
[10] Fakomogbon M A 2012 Instructional media in teaching and learning: a nigerian prespective Global Media Journal African Edition 6(2) pp. 218-228.
[11] Mariani S 2014 The Effectiveness of Learning by PBL Assisted Mathematics Pop Up Book Againsts The Spatial Ability in Grade VIII on Geometry Subject Matter International Journal of Education and Research 2 pp. 531-548
[12] Ulya S A 2017 The Development of Pop-up Book on the Role of Buffer in the Living Body European Journal of Social Sciences 4(4) pp 213-221
[13] Sukmadinata N S 2007 Metode penelitian pendidikan (Bandung: PT Remaja Rosda Karya)

Acknowledgement

On this opportunity, I would like to give my special thank to all of those who have given me valuable contributions in accomplishing this research.