

# 3D Geometric Shapes Of Pop-Up Book For Visually Disabled Students

Rahmita Nurul Muthmainnah, Ismah, Anwar Ilmar Ramadhan

**Abstract:** Regarding to the fact that there is limitation of both learning resources and tools for disabled students, especially visually disabled students, this research was conducted to create a mathematics learning media to facilitate the students with visual disability in understanding 3D geometric shapes such as cube, cuboid, triangular prism, triangular pyramid, and rectangular pyramid. This research is categorized as Research and Development (R&D) which adopted ADDIE as a R&D model that stands for Analysis, Design, Development, Implementation, and Evaluation. The aim of this research were to describe the development process and to produce mathematics learning media for visually disabled students, as well as determine the effectiveness of the 3D Geometric Shapes of Pop-Up Book. To determine its practicability and effectiveness, it requires a validation from the experts and a trial. Based on the result of testing the product by experts turned out to be the product, the 3D Geometric Shapes of Pop-Up Book, have reached a valid indicator in which score of each aspect are 91.67 % for its practical and simplicity, 90.28 % for its physical and look, 89.06 % for the Braille handwriting, and 93.75 % for the last aspect that is mathematics content. Good responses also given from the students, they gave the average score 87.27% which means that they feel satisfy with this product.

**Index Terms:** pop-up book, 3D geometric shapes, visually disabled students

## 1 INTRODUCTION

Every child in this world was born unique. There are some who were born with different conditions (physically and mentally) which is usually called Special Need. Special need children are children with special characteristics which is different from others in general which not always showed in the inability of mental, emotional or physical [1]. There are four major type of special need children: (1) Sensory Impaired like blind, visually impaired, deaf, and limited hearing; (2) Behavioral / Emotional such as ADD, bipolarize, and oppositional defiance disorder; (3) Developmental, for example down syndrome, autism, dyslexia, and processing disorder; and (4) Physical for instance muscular dystrophy, multiple sclerosis, and chronic asthma [2] Visually impaired / disabled children are children who experience obstacles in their eyesight that cause them to experience problems in daily activities, one of which is learning [3]. It can be concluded that the visually disabled child is a child who has lost some or all of his vision which causes him to have barriers to his learning and thus requires special education Eye as a sense of vision plays a big role in receiving and absorbing an information. Through eyesight, many different objects can be easily distinguished (based on its size, color, or shape). Moreover, people can define some object that placed far away and difficult to be reached, based on what they see. On the other hand, people who have a visual disability will use their other senses, in which sense of hearing and touching will become the main substitute of eye to accept the information [6-7]. In order to understand an object, they observe the object by using their sense of touching, then the imaginations or reflections they formed by touching will be combined as unity, so that the picturise of that object is gained [4].

The information they might get by touching is about the shape, weight, temperature, size, and position of the object, therefore the understanding the object's shape takes an important role in defining an object. Moreover, visually disabled people usually pay more attention in shape to distinguish the objects. Geometry is certainly one of the most difficult subjects to be teach to visually disabled pupils and one of the most useful at the same time, as it is necessary for the construction of their own mental space representation [5-6]. This mental representation is essential for education as well as for everyday tasks. Classic geometry teaching is based on visual modality such as: drawings, graphs, lines, and curves, all of these being unavailable to visually disabled people. Then, teacher will use haptic and auditory modality as a substitute for such visuals to teach simple geometric shapes. In learning geometry, young visually disabled students firstly operate with concrete objects; subsequently they develop their knowledge of shapes into knowledge of properties of shapes and then develop their comprehension of relationship between properties [7]. While for older visually disabled students, spatial reasoning includes inspecting and reflecting on proper mental models of images of shapes and spaces [8]. However, geometric concepts make sense only if they evoke an appropriate imagination of a spatial structure [9]. Since geometry subject tend to be visualize and abstract, then, a special method or instrument is required to teach geometry for them. The role of media in the learning process is very important. It can overcome the limitations of the students' experience that might be different from one to other [11]. Moreover, the use of media will bring the learning process go beyond the classroom and also improve the quality of learning process that may beneficial on the students' learning outcomes. There are many kinds of media that usually used in the learning process, in which all of them are classified into 6 main categories: graphics (such as photo, picture, sketch, comic, and poster); audio (such as ad-lib talk, short story, and lecture/script talk); projected still (such as slides and OHP); projected motion (such as TV, video, and computer); 3-dimension (such as miniature, diorama, and mock-ups); and multimedia interactive. Pop-up book is one example of 3-dimension media. It is a book-shaped that has movable parts and provides an interesting visualization when the page is loaded [12]. In the Pop-up book, the information is delivered in the form of an interesting picture since there is a part that can move, change or form when the book open. Based on its form

- Department of Mathematics Education, Faculty of Education, Universitas Muhammadiyah Jakarta.
- Department of Mathematics Education, Faculty of Education, Universitas Muhammadiyah Jakarta.
- Mechanical Engineering Department, Faculty of Engineering, Universitas Muhammadiyah Jakarta, Indonesia.
- Email: [rahmita.nurul@umi.ac.id](mailto:rahmita.nurul@umi.ac.id)

and movement, there are 6 types of Pop-up book, they are: transformations, volvelles, peepshow, pull-tabs, carousel, and box & cylinder. The Pop-up book that created in this research is "box and cylinder" since there will be a 3D geometric shapes (such as cube, cuboid, prism and pyramid) popped up in the middle of each page [13]. Based on the description above, the researcher was interested to conduct a R&D research to develop the 3D Geometric Shapes of Pop-Up Book for visually disabled students. The aim of this research were to develop a proper (valid, practice, and effective) mathematics learning media, the 3D Geometric Shapes of Pop-Up Book, and to find out the effectiveness of that learning media toward students' ability in understanding geometry.

## 2 RESEARCH METHOD

This research was conducted in Special School for visually disabled students namely SLB Pembina Tingkat Nasional, which located at Jln. Pertanian Raya No. 12 RT.06/RW.04 Lebak Bulus, Cilandak, Jakarta Selatan. The type of this research is Research and Development (R&D) which used to produce a particular product or develop the existing product as well as test the effectiveness of the product. ADDIE that stands for Analysis, Design, Development, Implementation, and Evaluation was adopted as a R&D model to develop the 3D Geometric Shapes of Pop-Up Book in this research. The development stages of the product, the 3D Geometric Shapes of Pop-Up Book, are as follows:

**Table 1. The 3D Geometric Shapes of Pop-Up Book Developmental Stages**

Development Stage	Description
Analysis	Conduct a needs analysis, identify problems (needs) of the visually disabled students. In the activity of a needs analysis, an analysis is performed of the syllabus which includes Competence Standard and Basic Competence, characteristics of visually disabled students, teaching materials / media that have been used to obtain information about media needed by learners in learning the competency have been programmed.
Design	This is accomplished by arranging opaque media. Media development initiated by compiling opaque media. The resulting media is expressed as opaque until the completion of the validation and testing. The design phase is the first step in making the learning media and must prepare everything that will be required, among other things: the creation of the design, etc.
Development	At this stage, the product was developed. The results of this phase is a product in the form of Pop-Up Book that has been structured in accordance with the standards of competence, basic competence and indicator where the three were already contained in any description of the matter. In this development phase, the 3D Geometric Shapes of Pop-Up Book is made according to the needs of the stage of development that has been designed, such as: the material, Braille typing, and coloring. Finally, at the end of this phase, the product was validated by the experts.
Implementation	This phase was conducted to determine the conformity / validity of the media with the subject matter. The media that has been validate by the experts were given to the students, and they were asked to give their response about the media.
Evaluation	To determine the success of learning media developed whether or not in accordance with the original expectations. Evaluation aims to make improvements to the learning media that have been developed.

Data were collected in this research through three aspects, in which each is used to meet the criteria of validity, practicality and effectiveness. First, validation by experts. The validation sheet was use in this research in order to get the data about expert validation. The validation sheet of the learning media by

the experts aims to determine the extent of the validity of the developed learning media, the 3D Geometric Shapes of Pop-Up Book. In this sheet, researchers use a scale of 5 (Excellent), 4 (Good), 3 (Fair), 2 (Poor), and 1 (Terrible). The validation sheet by the media expert contains: aspects of physical and look, terms of practical and simplicity, and terms of Braille handwriting. While the assessment sheet by the material and learning expert examine the mathematics content of the media. Next, observation. The observation conducted to see implementation of the media the 3D Geometric Shapes of Pop-Up Book for visually disabled students. The last one is the students' response. The students' responses obtained through Questionnaires. The questionnaire is aimed to find out the students' point of view about the 3D Geometric Shapes of Pop-Up Book. The questionnaire is prepared with 5 alternative answers "E" stand for Excellent, "G" for Good, "F" for Fair, "P" for Poor, and "T" for Terrible.

## 3 RESULTS AND DISCUSSION

This research is an R & D research which aimed to describe the process and result of developing a proper (valid, practice, and effective) mathematics learning media the 3D Geometric Shapes of Pop-Up Book for visually disabled student by using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. The process of developing the 3D Geometric Shapes of Pop-Up Book and its result described as follows:

### 3.1 Analysis

The first stage is Analysis. This phase was conducted to determine and define the necessary conditions by collected the information needed. The development of this media begins with analyzing the characteristics of students, curriculum, and learning tools. As a result, the visually disabled students need mathematics learning media to help them understand the material, one of which is geometry. From the preliminary research, the visually disabled students understand the planar shapes in their straight position for example, they describe the triangle as a planar shape with one horizontal line and two slope lines [14]; and parallelogram as a quadrilateral with two horizontal lines and two slope lines [15]. Those information, then, used to design the draft of the media, and also as a guide to develop the media such as in which position that the 3D geometric shape will be placed in the Pop-Up book pages.

### 3.2 Design

Secondly, is Design. In this stage the product the 3D Geometric Shapes of Pop-Up Book was sketched and designed. The content that will be discuss in this media are limited to the shape with flat surfaces, they are: cube, cuboid, triangular prism, triangular pyramid, and rectangular pyramid. The layout of each page of the Pop-Up Book were also designed in this stage.

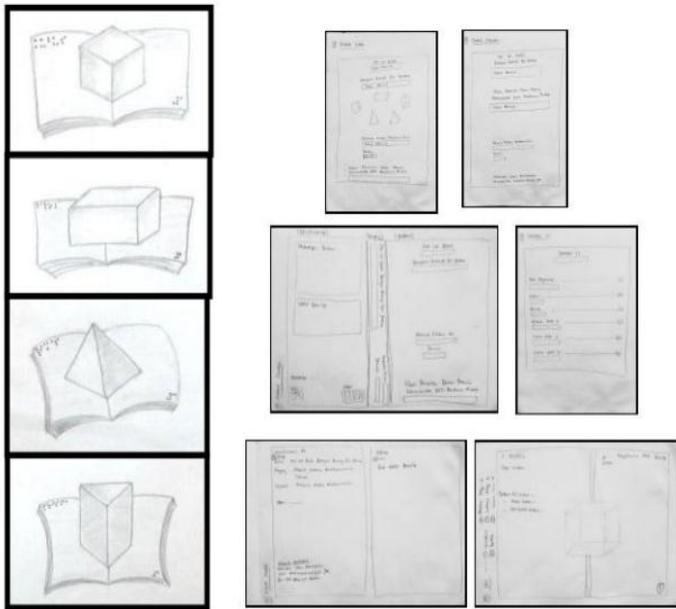


Figure 1. The Sketch of Pop-Up Book

3.3 Development

The next stage is Development. Before the product made, a thin paperboard was used as a trial to identify the cutting and the position of the shape.

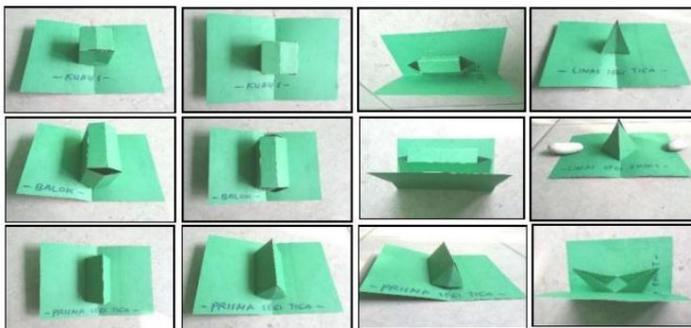


Figure 2. A trial product to identify the cutting and the position of the shapes

Once the cutting and the position studied, next the 3D Geometric Shapes of Pop-Up Book product was made. It made of 310 grams' A4 glossy paper for both the book pages and the shapes inside. Since this product developed for visually disabled students, then, all the information in this book should be in Braille text, therefore, all the text in this book are written in two versions, computer type and Braille type which manually handwritten using reglet and stillus. Figure 3 below shows the preliminary product of the 3D Geometric Shapes of Pop-Up Book. It can be seen from the picture that in the right pages the information about the shapes given in text while in the left pages, the information is written in Braille text.



Figure 3. The Preliminary Product of The Pop-Up Book

The preliminary product then validated by experts. Based on the result of testing the product by experts turned out to be the product, the 3D Geometric Shapes of Pop-Up Book, are valid and can be tested to assess their feasibility in the learning process can see Table 2.

Table 2. The result of the validation product by the experts

Aspect	Percentage
Practical and Simplicity	91.67 %
Physical and Look	90.28 %
Typography (Braille Handwriting)	89.06 %
Mathematics Content	93.75 %
<b>AVERAGE SCORE</b>	<b>91.19 %</b>

Based on Table 2, the preliminary media developed considered to be valid because of the result, where there is 91.19% with the category of excellent. Through the data obtained can be interpreted that the reviewer of media mentioned that from the viewpoint of its practical and simplicity to use, the product developed categorize as great in the score of 91.67%. By aspect of physical and look including size, material, durability, quality, and color, the product reach 90.28% with the category of very good or excellent. While in term of Braille handwriting aspect, it reaches 89.06% belong to the category good. Moreover, for the mathematics content, the product reaches the score 93.75 % with the category of excellent. After obtained the validation results and suggestions from experts, researchers revise the device according to expert advice. Next, the device was piloted in the test class.

### 3.4 Implementation

Next, the learning media was implemented in the implementation class which in this case was in SLB Pembina Tingkat Nasional. The students' responses of the product are as Table 3.

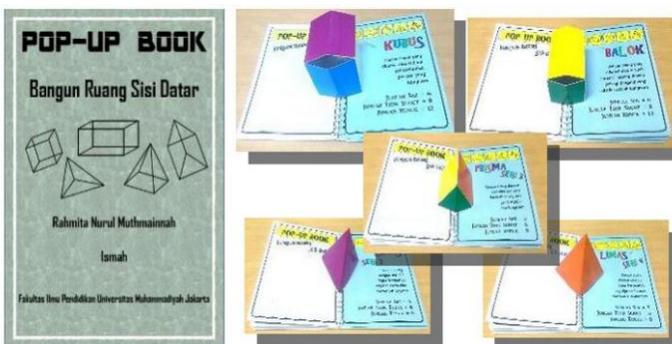
**Table 3. The students' responses of the product**

Aspect	Percentage
Practical	92.27 %
Physical and Look	86.82 %
Motivation	81.82 %
Help to understand the material	88.18 %
<b>AVERAGE SCORE</b>	<b>87.27 %</b>

The data above show that the students satisfy of the product, the 3D Geometric Shapes of Pop-Up Book, with average score 87,27%. From the Table 3, it can be interpreted that the product might help the student in understanding mathematics concept especially geometry, with the percentage of 88.18. Additionally, the physical and look of the product reach 86.82%. While in term of motivation to learn mathematics through the Pop-Up Book which give 81.82% of the responses. Furthermore, the product developed categorize as great for its practical which gain 92.27% students' responses.

### 3.5 Evaluation

Considering to the suggestions from the experts and students' responses, the learning media developed needs to be revised slightly in order to be judged worthy to be used in the field. Based on the analysis of qualitative data in the form of advice, there are some parts that need to be revised: (1) the color of the shape which is too plain (white), it should be changed to be colorful or it can be textured, for example put a brick pattern for pyramid or make a dice pattern on the cube; (2) the background of the Braille text should be dark to make it visible to non-visually disabled person. The final product of the 3D Geometric Shapes of Pop-Up Book as shown in the Figure 4.



**Figure 4. The Final Product of the Pop-Up Book**

## 4 CONCLUSION

Based on the result of testing the product by experts turned out to be the product, the 3D Geometric Shapes of Pop-Up Book, have reached a valid indicator in which score of each aspect are 91.67 % for its practical and simplicity, 90.28 % for its physical and look, 89.06 % for the Braille handwriting, and

93.75 % for the last aspect that is mathematics content. Good responses also given from the students, they gave the average score 87.27% which means that they feel satisfy with this product.

## ACKNOWLEDGMENT

The author would like to extend thanks to the chair and staffs of the Ministry of Research Technology and Higher Education Republic of Indonesia, give out funding this research.

## REFERENCES

- [1] Battista, M. T. 2007. The Development of Geometric and Spatial Thinking. In F. K. Lester (Ed.), Second Handbook of Research on Mathematics Teaching and Learning (pp. 843-908). Charlotte, NC: Information Age.
- [2] Berthelot, R. and Salin, M.H. 1998. "The role of pupil's spatial knowledge in the elementary teaching of geometry". In C. Mammana and V. Villani (Eds). Perspectives on the Teaching of Geometry for the 21st Century, 71-78. Dordrecht: Kluwer Academic Publishers.
- [3] Bluemel and Taylor. 2012. Pop-up Books A Guide For Teachers and Librarians. California: ABC-CLJO, LLC.
- [4] Erin, J.N. dan Koenig, A.J. 1997. "The Student with a Visual Disability and a Learning Disability". Journal of Learning Disabilities. Vol. 30 (3), pp. 309-320.
- [5] Klingerberg, O.G. 2012. "Conceptual Understanding of Shape and Space by Braille-Reading Norwegian Students in Elementary School". Journal of Visual Impairment & Blindness. Vol. 106 (8), pp. 453-465.
- [6] Mambela, S. 2018. "Tinjauan Umum Masalah Psikologis dan Masalah Sosial Individu Penyandang Tunanetra." Jurnal Buana Pendidikan. Vol. 14 (25), pp. 65-73.
- [7] Mangunsong, F. 2009. Psikologi dan Pendidikan Anak Berkebutuhan Khusus (Jilid 1). Jakarta: LP3S UI.
- [8] Miarso, Y. 2009. Menyemai Benih Teknologi Pendidikan. Jakarta: Kencana Pranada Media Group.
- [9] Moerdiani, S. 1987. Psikologi anak luar biasa. Bandung: Universitas Islam Nusantara.
- [10] Muthmainnah, R.N. 2015. "Pemahaman Siswa Tunanetra (Buta Total Sejak Lahir dan Sejak Waktu Tertentu) terhadap Bangun Segitiga". FIBONACCI: Jurnal Pendidikan Matematika dan Matematika. 1 (1), pp. 15-27. ISSN: 2460-7797.
- [11] Muthmainnah, R.N. 2017. "Blind Students' Understanding of Quadrilateral". IMC 2016 Proceedings 1(1). pp. 882-888. ISBN: 978-602-17688-9-1. [online] <https://jurnal.umj.ac.id/index.php/IMC/article/view/1284>
- [12] Tall, D. 2013. How Humans Learn to Think Mathematically: Exploring the Three Worlds of Mathematics (Learning in Doing: Social, Cognitive and Computational Perspectives). Cambridge: Cambridge University Press. doi:10.1017/CBO9781139565202
- [13] Thinus-Blanc, C. and Gaunet, F. 1997. "Space representations in the blind : vision as a spatial sense?". Psychological Bulletin. Vol. 121, pp. 20-42.
- [14] Van Hiele, P.M. 1986. Structure and insight. Orlando, FL: Academic Press.
- [15] Wahyuni, R. 2017. "Buku Gizi Braille sebagai Media Pendidikan untuk Meningkatkan Pengetahuan Anak Tunanetra." HIGEIA (Journal of Public Health Research and Development. Vol. 1 (1), pp. 59-64.