

Designing a Math Picture Book to Stimulate Primary School Students' Understanding of Properties of 2-D Shapes

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Abstract

This study aims to determine the feasibility of a math picture book (MPB) on the properties of 2-D shapes designed for primary students, and to find out how it can stimulate primary students' understanding about the properties of 2-D shapes. The method used in this research is design research based on Plomp's development model. The development research was carried out from designing MPB, validating with two experts, and testing with primary students in two stages, namely one-to-one and small group experiments. Based on experts' reviews, the designed MPB met very valid criteria, and the students and teachers also provided positive responses to the quality of designed MPBs. From experimenting it to six primary students in the experiment, it shows that students could explain the properties of 2-D shapes after reading the MPB. Therefore, the developed MPB had a positive impact on students' understand the properties of 2-D shapes.

Keywords: *design research; math picture book; properties of 2-D shapes; students' understanding*

1. INTRODUCTION

Mathematics is an important part in the field of science. Chotimah (in Tan et al., 2020) states that mathematics is one of the subjects that is closely related to real life, many things or problems around us that require mathematics. Mathematics needs to be given to all students starting from elementary school to equip them with the ability to think logically, analytically, systematically, critically and creatively as well as the ability to work together (Yuniarti, et al

2018). Mastery of mathematical contents is a must in structuring human reasoning and decision making in the current era of competitive competition. Mathematics subjects emphasize more on activities in reasoning, not on the results of experiments or observations, mathematics is formed because of human thinking related to ideas, processes, and reasoning.

Mathematics is a subject consisting mostly of abstract models with some symbolic structure. The abstract nature

of mathematics is sometimes a challenge for young students (Lely et al., 2020; Syafitri et al., 2020). To facilitate understanding of mathematics, early childhood teachers should strive to develop pedagogies that allow for a learning environment in which children have the opportunity to relate their new knowledge to their real life experiences (An, et al 2019).

In everyday life mathematics is needed to solve all problems, but many students do not like mathematics, because mathematics is considered a subject that difficult, complicated and boring (Liberna, 2018). One of the problems in learning mathematics is the low ability of students to solve problems related to everyday life. In the process of learning mathematics, students only memorize the knowledge provided by the teacher and are less able to use this knowledge when facing problems in real life (Zulkarnain, 2015). Problem solving skills must be possessed by students to train them to get used to dealing with various problems, both problems in mathematics, problems in other fields of study and problems in everyday life that are increasingly complex. Therefore, students' ability to solve mathematical problems needs to be continuously trained in order to solve the problems they face (Adhar, 2012).

To assist students in connecting reality with mathematics, teachers can use instructional media or design contextual-based learning (Winanda et al., 2020). The use of mathematics picture books can be an alternative in

helping students understand the relationship between mathematics and real life. Research conducted by Van den Heuvel-Panhuizen, Van Den Boogaard, & Doig. (2009), illustrates that a child reading a picture book can stimulate mathematical thinking about geometry, data representation, and measurement. The use of picture books can also explore and broaden the initial understanding of concepts related to mathematics.

Several studies have found that picture book media is used as a relatively easy-to-use communication tool for students in 2-D-shaped materials (Marwati et al., 2020). However, the use of reading materials in the form of picture story books as learning resources is still not optimal, as well as the availability of illustrated story books for learning Mathematics, especially geometry material, has not been widely developed, teachers only rely on textbooks as learning resources and are not even given concrete examples of 2-D shapes.

Based on this, this study intends to develop a picture book on the subject of the properties of 2-D shapes. For this reason, the authors are interested in designing a Mathematical Picture Book (MPB) and seeing how MPB is able to stimulate students to understand mathematical concepts about the properties of 2-D shapes.

Learning mathematics by using picture books is able to concretize something abstract through stories and pictures. Picture books can help students concretize abstract things through pictures and stories between real life

problems and the abstract world of mathematical knowledge (Maulana, 2009).

a. Math Picture Book

Mathematics Picture Book is a book that contains a combination of text, pictures, and mathematical concepts that are interrelated and in accordance with the situations faced by students in everyday life (Putra et al., 2019). Picture books include representational images (i.e., images that depict only the mathematical content provided in the text) elicited more math-related utterances, in contrast to images with an informational function (i.e., images that represented more information than what was written in the text, which rendered information to construct meaning). These results suggest that combining text and images with the same content (i.e., representational images) offers more opportunities to engage children mathematically, in contrast to combining text and images with different content i.e., informational images. (Elia et al., 2010)

From the existing understanding, the researcher argues that this math picture book is an illustrated media whose contents are about stimulating students related to mathematical content. The main purpose of this math picture book is to provide encouragement or a good stimulus in the level of student understanding and can help students to more easily understand the material given by the teacher. This math picture book measures 210 x 297 mm or the

equivalent of A4 paper size and is equipped with attractive pictures and colors. The use of mathematics picture books in helping learning to read has the following objectives (Jenkins, 2010): (1) Stimulate mathematical discussion; (2) Introducing and developing abstract mathematical concepts that lead to relevant and interesting mathematical activities.

b. Media as a Stimulus for Students' Knowledge

The term stimulus according to the general dictionary Indonesian is defined as a stimulus for organisms (body parts or other receptors) to become active (Sugono, 2008). Stimulus can be interpreted as a factor that affects the internal conditions of living things (Hardianto, 2019). In the general Indonesian dictionary, it is explained that to stimulate is to provide a stimulus to express various creative new ideas (Sugono, 2008). Stimulus means a way that someone does in overcoming a problem so that it can solve the problem in the teaching and learning process in the classroom. Basically, teaching and learning activities in the classroom require a good stimulus in fostering student learning creativity.

Based on the description above, the stimulation of student knowledge is a stimulus or encouragement given to students through the media to stimulate student knowledge, namely through learning activities using MPB. In addition, stimulating student knowledge is also an activity to encourage students in teaching

and learning activities, if students are not interested in learning then we as teachers must always encourage students to be active in learning.

c. Two-dimensional figure

2-D shape is a science related to the recognition and measurement of shapes (Elfawati, 2012) Meanwhile, according to Rohman et al. (2017) 2-D shapes are two-dimensional shapes that only have length and width that are limited by straight or curved lines. 2-D shapes have two elements, namely length and width. 2-D shape has parts, namely: (1) Side is a line segment that limits a plane or 2-D figure; (2) An angle is a part that lies between two sides and meets at one point; (3) A diagonal is a line that joins two non-adjacent angles.

2. METHOD

This study uses the method of design research (DR). Design is a plan that can be poured through pictures or directly into the shape of the object that is the target (Sumaryati, 2013). Design-based research is a formative approach to research, in which a process or product is considered, designed, developed, and improved through a cycle of validation, observation, analysis, and redesign, with systematic feedback from end users (Stephan, 2014).

The development model used is the Plomp model (Plomp, 2013). The Plomp model is used in this study because it is specific enough to make an effective product model, the steps do not cause new problems, are acceptable and do not

conflict, and are clear in terms of development planning at each stage. Plomp (2013) said that there are three phases, namely the initial research phase, the development or prototyping phase (prototyping phase), and the assessment phase.

a. Preliminary research

The initial research stage is a careful observation of the ongoing learning conditions. By conducting needs analysis (to find out the main problems needed in developing learning tools), curriculum analysis, concept analysis, and analysis of student characteristics (covering cognitive level, age, learning style, and student motivation, learning tools are produced according to student characteristics).

b. Development or prototyping phase

At this stage, the design of mathematics learning devices on 2-D shapes is carried out. This stage aims to prepare a prototype model and the required model support devices. To make it easier for researchers in the development process, a work plan and an estimated time are needed, then a self-evaluation is carried out by the researcher. The results of the analysis and subsequent revisions were given to 2 validators (expert reviews) to be validated. The results of the validation of the learning tools are then revised and after being said to be valid, an individual evaluation (one-to-one) is carried out. One-on-one evaluation was carried out

by three students with high, medium and low abilities. This was followed by a small group evaluation by six students. After that the results of the revision were tested on the research subject in this case as a field test. Products that have been tested in field tests must be products that have met the quality criteria. With the current situation where it is not possible to conduct face-to-face learning, due to the COVID-19 pandemic, this research did not reach the field test process. The expert validation test is used to test whether or not this picture book is valid to be given to students.

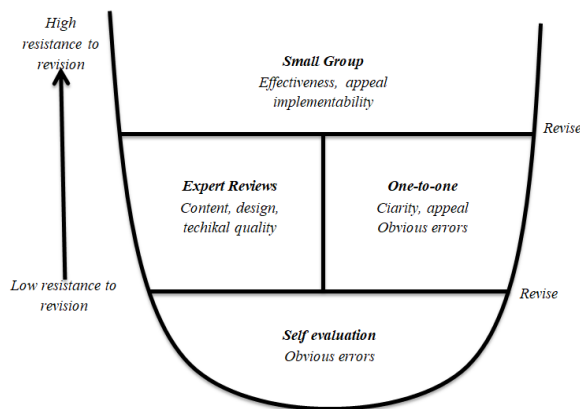


Figure 1. The formative evaluation layer of the Plomp model (in Saifudin & Mubarok, 2020)

Based on Figure 1, formative evaluation activities are carried out through self-evaluation; expert assessment (expert review); individual evaluation (one-to-one evaluation) and small group evaluation (small group evaluation) as follows: (1) Self-evaluation, Researchers examine or self-evaluate prototype 1 that has been designed. In this test the researcher has

made a prototype designed which is then checked whether the prototype made is in accordance with what is expected or what students need. After the inspection, an evaluation is carried out. From the results of the evaluation, it will be known whether the prototype that has been designed is feasible to be given to students or if there is a need for revision. Researchers try to do it objectively; (2) Expert review At this stage, experts are asked to evaluate or provide assessments and suggestions on product design to find out the shortcomings of product design and advantages, and pay attention to the expected product specifications, namely based on aspects of material, design, simplicity, compactness, emphasis and balance; (3) Individual evaluation (one-to-one evaluation) This stage is carried out on three students who have different abilities (heterogeneous). Students were asked to comment on the feasibility of the developed math picture book; (4) Small Group Evaluation This stage is carried out on six students who have heterogeneous abilities. Learners learn expertly are asked to evaluate or provide assessments and suggestions on product design to find out the shortcomings of product design and its advantages, and pay attention to the expected product specifications, namely based on aspects of material, design, simplicity, integration, emphasis and balance.

3. RESULTS

The first step taken by the researchers was preliminary research

which included analysis of needs, curriculum, student characteristics and analysis of mathematical concepts in elementary schools.

a. Stage of making a picture book sketch (Prototype Design)

The following are the stages in making a sketch of a mathematical picture book in 2-D shapes:

Book Concept

Math picture book that will be developed is made with a simple story concept, taking ideas or views in everyday life. The purpose of using simple language and taking the concept of stories in everyday life is so that children will find it easier to understand the meaning contained in reading the math picture book. The researcher designed a story about a family who did mutual cooperation with the family. With this, it is easier for children to understand the activities they are experiencing, because working together with the family is an activity that is often done in real life.

Characters

In making this picture story book, it is not far from the main character (table 1). The main character in this story is Ani. In addition, other characters in this story are Ani's father, Ani's mother and Udin who is Ani's younger brother.

Book Format and Size

Math picture bookit has a size of 21cm x 29.7cm equivalent to A4 size. It

has 25 pages consisting of 1 page for the cover, 1 page for the copyright sheet, 1 page for the introduction, 1 sheet for character introduction, 19 pages for content, 1 page for the author's biography and 1 back cover page.

Table 1. Explanation of characters in picture story books

Character name/ image	Characteristic features
Ani	Ani has long black hair and is loose (not tied), wears a long blue shirt, wears a black skirt
Ani's father	Ani's father has a beard, has a mustache, wears a cap/cap, wears a short white shirt and wears blue pants.
Ani's mother	Ani's mother wears a pink dress, has thick black hair, her mother's hair is tied at the back and wears an orange hair tie.
Ani's sister (Udin)	Ani's sister has straight black hair, wears an orange shirt and red pants

Book Content and Theme

The researcher took the contents of this math picture book, which was an imaginary essay from the researcher which was adapted to the survey of student needs analysis that had been carried out previously. This story is made with stories of experiences experienced by students when working together with their families. The content in the story also contains questions and answers about the properties of 2-D shapes to provide reinforcement for children.

The theme used in making picture story books is related to the world of

children and events that children have experienced directly. The language used in this story is also simple to make it easier for children to understand the contents of the story. The pictures used in the story also use simple pictures that children often encounter in the surrounding environment and are added with interesting colors.

Book Title

The title of the math picture book that the researcher made is "Together with the Family" (figure 2). The title the researcher uses because it is in accordance with the contents in the picture story book, the story describes the atmosphere when working together with the family where they encounter objects around that resemble 2-D shapes, then Ani as a character who always introduces or tells her sister and explains understanding of 2-D shapes and their properties in detail.



Figure 2. Cover and title of math picture book

Based on the cover image of the math picture book above, it is explained that Ani and mother are sweeping the house, father is cutting the grass and

Udin is helping to lift the garbage and then throwing it in the trash.

Image Design

The image design used in making this math picture book uses a cellphone and is assisted by the Ibis Paint X application. The images displayed in this math picture book are simple images that aim to facilitate children's understanding (figure 3). Making design drawings manually includes a background and pictures of other simple supporting objects. Below is a sketch of the image made by the designer.

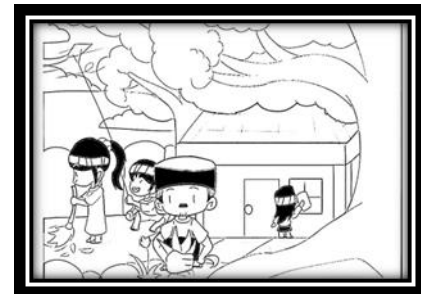


Figure 3. Sketch of a math picture book with the Ibis Paint X . application

Working Techniques

The working technique in making this math picture book uses 2 techniques. The first technique is to draw a sketch using the Ibis Paint X application until the coloring stage and the second technique is to use Microsoft Word 2010 to add and edit the story text, then convert it to Portable Document Format (PDF).

The figures bellows presented are the techniques for making math picture books:

- a. In the initial manufacturing technique, the researchers design a pattern of

dots and lines which are used as a design for an image. Judging from Figure 4 which is a sketch of an image that is still in black and white, it means that the sketch in the image has not been colored. After the image was finished and if it was right, the researchers continued to color the image using the Ibis Paint X application (Figure 5).

- b. This second technique has two stages of processing. For the first stage, the researcher writes a story on the image that has been colored using Microsoft Word 2011 (Figure 6), after all the images are given a story text and declared good, the next step is to change the file format to Portable Document Format (PDF) (Figure 7).

The colors used in this math picture book are adjusted to real colors, for example green leaves, blue sky colors, white clouds and then other colors will be adjusted to the object. This is done in order to attract more students' interest in reading this math picture book.



Figure 4. The sketch of the image has not been colored



Figure 5. The sketch of the image has been colored



Figure 6. Sketch of an image that has added story text to the image via Microsoft Word 2010



Figure 7. Sketch of an image that has been converted to Portable Document Format (PDF)

Typography

In making this math picture book the typographic style used is Arial (Figure 8). The researcher uses Arial typography style because the writing style includes letters that appear clear and helps readers to more easily remember the contents of the stories they read.

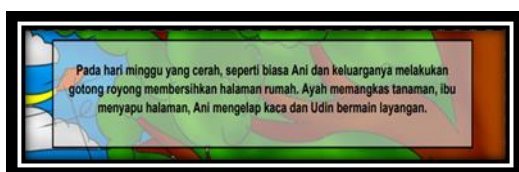


Figure 8. Typography used in the content of the math picture book

Printing Technique

The type of paper used to print the cover of the book is Ivory paper, while the type of paper used for the contents of the picture story book is Art Paper. Printing in the contents of this story book is printed back and forth due to make it easier for readers and increase the attractiveness of students to read the contents of the story. Initial printing uses Hourt Vrij Schrift (HVS) paper which will be used for the self-evaluation stage (Self Evaluation), the validation stage and the one-to-one and small group evaluation stage. This technique is used by researchers to minimize expenditure costs, so that the media will be printed on Hourt Vrij Schrift (HVS) paper first and after finishing until the final stage then printed using Ivory paper and Art Paper.

After getting problems from preliminary research, the next stage is the development or prototyping stage.

This stage is the stage of designing and making learning media in the form of math picture books. This design stage aims to design the presentation of the mathematical picture book media that will be used.

The making of this mathematical picture book begins with making a 2-D design or sketch that is related to real life, namely drawing objects that are often encountered in everyday life and making story texts that are in accordance with the designed images. After finishing designing the math picture book, the researcher conducted his own evaluation of the pictures, the content of the story and the writing of the text. Many errors were found, such as the accumulation of writing on the picture, too much writing on the picture and typos in the writing of the story. After the researcher revises the mathematical picture book media, the researcher gives the results of the revision to the expert or experts to be consulted and validated.

Learning media for mathematics picture books that have been designed and evaluated by themselves (Self Evaluation) are then validated by experts or validators. At this stage, produce a product that has been validated and revised based on input from the validator. These improvements are in the form of increasing the suitability of media and materials. Validation carried out by experts is given in the form of a questionnaire. There are 6 aspects that will be assessed by the validator after the math picture book is revised according to suggestions and input, namely the

material aspect, the design of the math picture book, simplicity, integration, emphasis, and balance.

Table 2. Material Expert Validation Score

No	Criteria	Percentage of Each Aspect (%)	Category Validation
1	The material presented is in accordance with the Basic Competence	75%	Valid
2	The content of the material presented is clear and can be understood by students	75%	Valid
3	Submission of material in the math picture book is illustrated with pictures so that students can easily understand the material presented in the math picture book	100%	Very Valid
4	The proverbs or terms used in the math picture book are in accordance with the students' thinking level	75%	Valid
5	The math picture book media used was developed appropriately to increase students' knowledge about the properties of 2-D shapes	100%	Very Valid
6	<i>Math picture book</i> developed according to the characteristics of elementary school students	100%	Very Valid
Validation Average		87.5%	Very Valid

The results from table 2 show that the average score of the assessment on the material aspect shows the number 87.5% with a very valid category. In this material aspect, there are six statements. From the assessment obtained, it can be said that the math picture book described is appropriate for the learning objectives. Submission of material is very clearly stated in the math picture book. The proverbs or terms used in the math picture book are in accordance with the students' thinking level and the sentences used are very effective and easy to understand.

Table 3. Media Expert Validation Score

No	Assessment Aspect	Percentage of Each Aspect (%)	Category Validation
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1	Math picture book design	87.5%	Very Valid
2	Simplicity	90%	Very Valid
3	Cohesiveness	93.75%	Very Valid
4	Emphasis	87.5%	Very Valid
5	Balance	100%	Very Valid
Validation Average		91.75%	Very Valid

The results from table 3 show that the average score of the assessment shows the number 91.75% with a very valid category. In the media aspect, there are five statements that are assessed, namely the design of the math picture book, simplicity, cohesiveness, emphasis and balance. In the design aspect of the math picture book, there are six criteria, the simplicity aspect is

five criteria, the integration aspect is four criteria, the emphasis is two criteria and the balance aspect is two criteria. In the aspects assessed related to image design, coloring, suitability of stories, story scenes, language and types of writing used in making math picture books, they are good and in accordance with the characteristics of students in general. The pictures presented are in accordance with students' activities in everyday life which are made to make it easier for students to understand the content of the math picture book story.

Table 4. Average Validation Score

No	Assessment Aspect	Aspect Percentage (%)	Category Validation
1	Ingredients	87.5%	Very Valid
2	Media	91.75%	Very Valid
Validation Average		89.62%	Very Valid

From the results of the calculations in table 4, it shows that the mathematical picture book developed with the material properties of 2-D shapes gets an average score of 89.62% with a very valid category. The results of the validation of material experts and media experts from all aspects stated that the initial product was categorized as very valid but still needed improvements to the media in several math picture books. After the mathematical picture book media is declared valid, then an individual evaluation (one-to-one) is carried out.

Based on the results of individual trials (one-to-one) that have been carried out, it is generally known that students are able to mention the names of 2-D

shapes in their entirety, knowing a little about the properties of existing 2-D shapes. we often encounter, for example a 2-D square shape, square shape. length, triangle and circle, but other 2-D shapes such as parallelogram, trapezoid, kite and rhombus, some do not understand their basic nature. Only students with high abilities can know the properties of 2-D shapes, for students with moderate abilities can also know the properties of 2-D shapes even though only a little, and for students with low abilities still have difficulty understanding the properties of 2-D shapes. The following is a conversation with students.

After completing the individual evaluation (one-to-one), then a small group evaluation is carried out. This evaluation activity was carried out with six students and three teachers, and the results are presented in table 6.

Table 6. Results of Small Group Evaluation by Students

No	Assessment Aspect	Percentage of Assessment Aspect (%)	Category
1.	Interest in Math Picture Books	94.16%	Very Valid
2.	Material retention	95.83%	Very Valid
3.	Appearance	91.66%	Very Valid
4.	Math Picture Book Presentation	95, 83%	Very Valid
Average amount Category		94, 37%	Very Valid

Based on the results of the small group evaluation that has been carried out, it is obtained an average of 94.37%

with a very valid category. By getting an average score of 94.37% then *math picture book* entitled "Gotong royong with the family" is very appropriate as a medium of learning used in elementary school students. In learning, there are four aspects that are assessed by students.

Based on the results obtained from the teacher's response, it shows an average percentage of 91.66% with a very valid category (Table 7). In this research are *math picture book* which have the properties of a 2-D shape are very valid to be used as learning media materials in the classroom. In the assessment of responses to the media trial, there are three aspects that are assessed by the teacher.

Table 7. Teacher Response Assessment Results

No	Assessment Aspect	Percentage of Assessment Aspect (%)	Category
1.	Media Usage	88.88%	Very Valid
2.	Interest in Math Picture Books	94.44%	Very Valid
3.	Math Picture Book Presentation	91.66%	Very Valid
Average amount Category		91.66%	Very Valid

Based on the results of the feasibility conducted by six students or small groups and three classroom teachers, the average percentage of learning media in the form of *math picture book* as follows.

Table 8. Product Feasibility Test Results

Not	Test Results	Average score (%)	Category
1.	Student response test	94.37%	Very Worthy
2.	Teacher response test	91.66%	Very Worthy
Average amount Category		93.01%	Very Worthy

The results obtained from the feasibility test show that the media *math picture book* obtained an average score of 93.01% with a very decent category. Overall, the media developed by the researcher is very suitable to be used as a medium of learning in the classroom, especially mathematics. The form of image designs and stories that are put together into *math picture book*. This is the latest innovation in teaching the material properties of 2-D shapes in the classroom, with stories that contain elements of students' daily activities, the images and colors presented can attract students' interest in learning. So that students can learn mathematics with the material properties of 2-D shapes independently or with the guidance of teachers at school.

4. DISCUSSION

This study aims to determine the feasibility of the math picture book learning media about the properties of 2-D shapes. This study also aims to find out how the math picture book is able to stimulate students in understanding the properties of 2-D material. The development of this learning media uses realistic content that confronts students with contextual problems related to

everyday life. The material contained in the development of this math picture book is about the properties of 2-D shapes.

Based on the validity test conducted with media experts, the learning is in the form of: *math picture book* this has been valid. Further validity test with material experts who stated that the math picture book media is also very valid if used on the material properties of 2-D shapes. The value of the validity is showing a very valid category. This means that the research used is feasible to be tested on students. In line with the opinion of Sells and Richey in (Haviz, 2016) that a development research is a systematic analysis of the design, development and evaluation, learning processes and products that must meet the criteria of effectiveness, validity, and practicality. The media must meet the criteria of the experts, validated by the experts.

The valid media were tested with elementary school students through two stages, namely the application of individuals (one-to-one) and application of small groups (small group). The purpose of the trial is to see how the media is able to stimulate students in understanding the material about the properties of 2-D shapes. From the results of trials conducted, it shows that after reading the media, students are able to explain the properties of 2-D shapes. This shows that the developed media has had a positive impact on students to understand the concept of the properties of 2-D shapes. This statement is in line with research

conducted by Krisjaya, (2018) which states that the learning media in the form of picture books with 2-D-shaped content is very feasible as student literacy material and as a medium for supporting lessons by teachers. This is shown because the picture story book includes five basic principles of Tomlinson (1998) which are to have a strong influence on students, make it easier for students to learn, according to the learning material, have a positive effect on students and provide feedback for students.

Math picture book when tested in limited groups with small groups, the math picture book learning media was able to stimulate students to understand the material properties of 2-D shapes. The process carried out to stimulate it is by students reading books independently and alternately and through discussions with friends. Then students were asked about what they understood from the math picture book, they were able to explain the properties of 2-D shapes. This is also supported by the results of a study conducted by Marwati et al. (2020) who found that picture books were able to make students very excited and enthusiastic when participating in learning using picture story books. This is also in line with the stimulus concept contained in the SOR theory, namely Stimulus-Organism-Response. The principle of this theory is a response which is a back reaction from individuals when receiving stimuli from a media. It can be interpreted that a stimulus that if

students are given an object or stimulus, they can respond from what they get.

5. CONCLUSION

From the results of the experiments conducted, it shows that after reading the media picture books of mathematics students are able to explain the properties of 2-D shapes. This shows that the developed media has had a positive impact on students in understanding the concept of 2-D shapes.

In general, for this research, it is recommended for teachers to be able to use media to deliver subject matter to students. Media is very important to use in learning. Because learning media is a technology that can make it easier for teachers to convey material, deliver messages or intentions to students and as a means of communication in a tangible form, so it is unlikely that students feel bored in learning.

For further researchers, it is necessary to conduct a field test (Field Test) to students so that it can be known further how this MPB is able to stimulate students' knowledge about the properties of 2-D shapes through learning media in the form of math picture books. For teachers, there is a need for new innovations regarding learning media to provide stimulus to students such as this MPB so that students can better understand a material in detail independently or with the help of teachers at school. For schools, it is necessary to develop learning media in the form of picture story books that can

be reproduced through the school library so that it can attract students' interest to read stories that contain lessons and can increase students' knowledge, especially mathematics.

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