**Development of Math Manipulatives Media on The Topic of Special Angle in Various Quadrants**

**U Faizah1, A Qohar2\***

1MA Miftahul Huda, Jl. Pesantren III Kepanjen Malang 65163 Indonesia

2Mathematics Department, Universitas Negeri Malang, Jl Semarang 5 Malang 65145 Indonesia.

\*abd.qohar.fmipa@um.ac.id

**Abstract**. A special angle in learning mathematics is one of the topics in mathematics that is considered difficult by students. Manipulative media can be used to assist students in learning the concepts of these special angles. With mathematical manipulatives, the concept of special angles can be made more concrete so that it is easier for students to understand the concept. This research is a development research that aims to produce learning media in the form of a special angle teaching aid. The developed manipulative media is useful for studying the values of special angles in various quadrants. The development research used refers to the Borg and Gall model which has been modified into five phases: research and collection, planning, product design development, validation, and testing. Research subjects were 30 students of class X Miftahul Huda Kepanjen Senior High School. Validation test results show that the manipulatives media is valid with a score of 86.45%. Product trials for students showed that the manipulatives media received positive responses from students with a score of 85.25%. Therefore, the developed manipulatives media meets valid and practical quality aspects. This study also shows that the manipulatives media can facilitate and motivate student learning.

1. **Introduction**

Mathematics and its application play an important role in everyday life, such as in technology, production, information, management, economic transactions, decision making, etc. [1]. However, many students still consider mathematics as a scary subject that becomes a burden on students, especially those related to geometry and trigonometry [2]. This is due to the lack of understanding of mathematical concepts resulting in anxiety, fear or embarrassment on students for their incomprehension should a teacher asks them to solve mathematical problems [3]. Therefore, mathematics learning that can involve the association of abstract mathematical objects with real objects experienced by students is needed. Physically active lessons can benefit mathematics learning [4].

Here the teacher plays an important role in creating fun learning [5], and it is also important for teachers to know students individually[6]. One important solution that teachers can use to increase students' interest and understanding in learning mathematics is the use of learning media [7]. Because the use of learning media will create a more interactive learning between teachers and students. According to [8], the benefits of learning media are as follows: (1) learning becomes more interesting for students, so it can stimulate student learning motivation; (2) learning material will be very clear, so it can be easily understood; (3) learning methods will vary, not only verbal communication or lecture by the teacher, but also meaningful learning activities experienced directly by students. In the Process Standards of Primary and Secondary Education also mentioned that the preparation of learning tools is an integral part of learning plan that is designed in the form of syllabus, lesson plans, and learning preparation [7].

  Trigonometry is one of the topics in mathematics that has many benefits in daily life, including: in the field of triangulation techniques used in astronomy to calculate distances to the nearest star; in geography, to count between certain points; and in satellite navigation systems. Other fields that also use trigonometry include various branches in physics, land surveying and geodesy, architecture, phonetics, economics, electrical engineering, mechanical engineering, civil engineering, computers, cartography, and many more [9]. However, it is considered difficult by high school students [2], [10], [11].

One of the causes of students’ low understanding in trigonometry is because of the habit of memorizing formulas instead of being directly involved in the process of finding the concept of trigonometric comparisons [12]. Trigonometry is a topic of interconnected and sustainable mathematics that exists at every level of the high school. So, when students do not understand the material at the beginning, it will affect further misunderstanding of the next topic. Therefore, learning media or teaching aids are needed to assist students in understanding trigonometric concepts.

An example of existed learning media related to trigonometry topics for example is the development of media with MATLAB software (GUI) to determine the total and difference of two angles. This media can be used in class classically as well as independently [12]. Another example of learning media is the Smart Binocular learning media which is used to calculate the height and width of an object. The Smart Binocular is made of wood with a pipe attached to a protractor and a wooden block as a support. Smart Binocular was developed through several experiments, the firstly made product is the mini-theodolite product that could directly be used to check the elevation angle of the observer with an object, but was limited to calculation of the height of an object [9]. One of the most common learning media of trigonometry is the use of GeoGebra application [13], [14], so that manipulative media is needed as an alternative learning media.

Based on the description above, the researcher was interested in conducting research on the development of trigonometric angle manipulative media, because this visual aid has many benefits. This manipulative media makes it easier for teachers to teach concepts about special angles in various quadrants. Even later, this manipulative can be used to determine trigonometric values at all angles from 0 to 360 degrees. When learning material from special angles in various quadrants using the developed manipulative media, students feel invited to find concepts, so that learning becomes more meaningful.

1. **Experimental Methods**

The type of research used is Research and Development (R&D) with reference to the Borg and Gall models which have been modified into five phases as follows: research and collection, planning, product design development, validation, main areas of testing. Research and development are used because researchers want to develop manipulatives to determine trigonometric values in various quadrants. Also, when collecting data in the field, that is in preliminary research to gather more qualitative data. The next stage, the product effectiveness test, is conducted by an experimental / quantitative method. And data acquisition will be analyzed qualitative-narratively and in the form of quantitative calculations. This type of research and development is considered suitable to be used to assist researchers in developing learning media for trigonometry learning material for students of class X with a total of 30 students. For research purpose, the location of learning media development is Miftahul Huda Kepanjen Senior High School.

In this Procedure of Research and Development, the researchers refer to a research design modification and model development according to Borg and Gall that uses a waterfall flow at the development stage [9] with the steps as follows:

Individual Testing

Revision

Small Group Testing

Revision

Field Testing

Revision

Deployment and Report

Analysis of Needs

Media Planning

Product Development

**Figure** 1. Waterfall flowchart of the development stage

All ten steps in Figure 1 are not standard things to be followed. The steps taken can be adjusted to the needs of researchers, with the changes needed in this research and development using 5 stages due to time limitation. Data was obtained from research instrument of learning tools in the form of validation sheets, test results and student questionnaire responses.

 The purpose of data analysis is to illustrate the validity and practicality of the media developed. Validation is measured using a validation sheet by providing a validation sheet to the validator and aimed to find out how valid the developed media and material are, so that it can be used by students. Practically is measured using student response questionnaire by giving questionnaires to students, and aimed to determine the feasibility of the media.

1. **Results and Discussion**

Researchers will explain the results of media development by the following stages:

*Research and accumulation*. The results of preliminary observations made by researchers at MA Miftahul Huda showed that the teaching materials used by the teacher during the mathematics learning process, especially the trigonometry material in class, only used textbooks. So that the use of manipulative media is needed for the learning process in mathematics classes on the topic of trigonometry. The manipulatives media developed in this study were named SUTRI. This manipulative media is used to determine the angular values of Sine, Cosine, Tangent, Cosecant, Secant and Cotangent in various quadrants. Where the angle value ranging from 0o to 360o can be calculated using the manipulative media. In the manipulative media, there is a unit circle, it is called the unit circle because the circle has the radius of 1 unit from the coordinate (0,0).

*Product planning* conducted using the following stages: materials and equipment selection is important in the making of media products. The manipulative media was developed using the following materials: Colored Styrofoam with a thickness of 1 cm, length of 30 cm and width of 25 cm, 3600 bow, asturo paper size 30 cm x 25 cm, double tip as asturo paper adhesive with Styrofoam, bol yarn as needed, and a ruler. The equipment’s needed in the development of manipulative media are as follows: marker, pencil, calipers, scissors, ruler, sticky tape, and cutter. All materials and tools that are designed and used by researchers are chosen by considering a simple media with many benefits, which aims to facilitate the development process and obtain product results that are in accordance with the learning objectives.

The steps in using manipulative media are as follows: (1) direct the yarn at the intended angle; (2) hold the yarn that was directed earlier; (3) measure the length of the perpendicular sides facing the thread with a ruler (the unit in manipulative is dm); (4) observe the direction of the x axis and the y axis.

The *product design development* stagestarts from the planning of the initial product development process until feasibility test in the University level. Before the establishment of the media, the preparation for the development of draft product was to prepare the materials needed in the making of media and material content for use in media which was a trigonometric material for determining the value of trigonometric special angles (between 00 to 3600) in class X. With the use of media, teacher can explain the concept of trigonometry, especially the determination of the trigonometric special angles between 00 and 3600 easily. This learning media can be used by students both independently and in groups. Because the media is designed to be interesting and as easy as possible for students.

The *validation* stage, after the initial product is developed, an expert testing or validation is carried out by a media expert lecturer, a master student in mathematics education and a mathematics teacher. The result of the validator's assessment of the media can be seen in Table 1.

**Table** 1. Media validation results

|  |  |
| --- | --- |
| Criteria assessed | Average score of each aspect |
| Learning media contents |
| Learning media can help students learn mathematics | 3.3 |
| Learning media can help students build understanding of mathematics | 3.3 |
| The activities provided enable positive interactions between students and learning media | 3.67 |
| Activities in the use of learning media in accordance with learning objectives | 3.67 |
| Learning media does not cause ambiguity | 3.3 |
| Learning media benefits |
| Learning media can be used by students to achieve learning objectives | 3.67 |
| Learning media can support mathematics learning in schools | 3.67 |
| Learning media can encourage students to be more active | 4 |
| Form and display(manipulative / physical media) |
| Learning media display is attractive | 3 |
| Proportional form of learning media | 3 |
| Validity score | 3.458 |

Based on Table 1, it can be seen that the validity score (Va) obtained is 3.458 or 86.45%. The score shows that learning media can be considered valid. In the media expert testing, a revision was made to the media, because styrofoam was considered less durable, hence researchers replaced it with acrylic material to make it more durable as well as to make it look more attractive for students.

The following is media images after the revision.



**Figure** 2. SUTRI media after revision

After the revision, the media is tested on students. The test was conducted to assess student responses to the media developed. In the test, students were given questionnaires and were asked to rate the media. The result of the questionnaire analysis of student responses can be seen in Table 2 below:

**Table** 2. Student responses to media development

|  |  |
| --- | --- |
| **Criteria Assessed** | **Average score of each aspect** |
| **Material presentation**  |
| I use mathematics learning media easily | 3,4 |
| Presentation of problems in the mathematics learning media helped me understand mathematical concepts  | 3,4 |
| I love learning mathematics through this learning media because it is interesting | 3,5 |
| This learning media makes me love mathematics | 3,5 |
| This learning media makes me want to understand mathematics even further | 3,4 |
| **Language and display** |
| The instructions and information presented are easy for me to understand | 3,3 |
| Learning media display is attractive | 3,4 |
| **Validity score** | 3,41 |

From the student response test, it can be seen that the SUTRI learning media received positive responses from students with a validity score of 3.41 or 85.25%. In the implementation of this trial, it was carried out in group learning. This is done so that students can discuss using media to find and understand mathematical concepts. In group learning using this media, the role of friends in the group is very important to understand mathematical concepts[15].

This media development research resulted in a learning media called SUTRI (Trigonometric Angle). This name is given so that students can better remember when faced with problems related to trigonometric angles. Because the use of media in learning will provide real experiences for students [16] and motivate them more to learn [17] the next topics. Concrete experiences or activities are also valuable learning [18]. The learning media itself can function as an interesting source of learning [19], and have a positive impact on children [20], [21].

 The process of making SUTRI learning media underwent a revision of the material used. Because previously, Styrofoam materials were considered less durable when used continuously by students. So, the validator team suggested to replace it with a stronger materials and more attractive appearance without changing the initial function of the media used. Researchers replaced it with acrylic material. And in fact, this acrylic material is easier to use in learning practice and in accordance with the purpose of creating a learning media [16], [17].

Based on the results of product validation and testing, it can be seen that the learning media in the form of SUTRI teaching aids to determine the special angle values in various quadrants is declared as valid. The validity of SUTRI media is based on the result of the media expert validation which showed an average score of 3.458 or 86.45%. Based on product testing on a small scale also shows positive responses of students. From the student response test, it can be seen that the SUTRI learning media received positive responses from students with a validity score of 3.41 or 85.25%. Students are also motivated to learn deeper in mathematics. This is in agreement with previous research that the use of media in learning can increase learning motivation [22]–[24]. With the existence of student motivation, the tendency of students to learn increases, this can result in the achievement of learning outcomes [25].

 The developed SUTRI learning media not only can be used to determine special angle values in various quadrants, but also to calculate all trigonometric angle values from 00 to 3600. In general, the advantages of SUTRI learning media in addition to the tools that are simple and easy to make, but the benefits exceed the purpose of making this media. Where at first the researchers only intended to use it in determining special angles in various quadrants, but in reality, after being tested, it could be used to calculate all angles between 00 to 3600.

 Besides the advantages of SUTRI learning media, there are a few disadvantages as follows: SUTRI media still requires a calculator to make it more efficient in the use of study time, due to many trigonometric angle values that contain decimal values with a lot of numbers placed behind the comma; and still needed conversion of decimal numbers in the root form.

1. **Conclusion**

SUTRI learning media is one alternative media that can be used by teachers as an interesting learning resource in teaching trigonometry, especially the determination of the values of special angles in various quadrants. The result of the validation test of media development indicates that the media is valid with an average score of 3.458 or 86.45%. Product testing on students showed that the media received a positive response from students with an average score of 3.41 or 85.25%. From this, it can be seen that through the worthiness validity test of using media and student responses testing in a small scale, SUTRI learning media is declared as valid and receive positive responses from students and is proven to be able to increase student learning motivation.

 In the development of SUTRI media, there were students who suggested making media with a rather small size, as small as a book, so that it is easier to be carried around. Based on the findings of researchers in the small-scale testing, researchers suggest for further researches to make similar learning media and more interesting and reduced in size.

1. **References**

[1] Ernest P Skovsmose O Paul J and Maria V B, *The Philosophy of Mathematics Education* .

[2] Bernard M Sumarna A Rolina R and Akbar P, 2019 Development of high school student work sheets using VBA for microsoft word trigonometry materials Development of high school student work sheets using VBA for microsoft word trigonometry materials.

[3] Zakaria E and Nordin N, 2008 The Effects of Mathematics Anxiety on Matriculation Students as Related to Motivation and February.

[4] Vetter M O’Connor H T O’Dwyer N Chau J and Orr R, 2020 “Maths on the move”: Effectiveness of physically-active lessons for learning maths and increasing physical activity in primary school students *J. Sci. Med. Sport*.

[5] Tambunan H, 2018 The Dominant Factor of Teacher ’ s Role as A Motivator of Students ’ Interest and Motivation in Mathematics Achievement **11**, 4 p. 144–151.

[6] Sheppard M E and Wieman R, 2020 What do teachers need? Math and special education teacher educators’ perceptions of essential teacher knowledge and experience *J. Math. Behav.* **59**, July 2019 p. 100798.

[7] Widodo S A, 2018 Selection of Learning Media Mathematics for Junior School Students **17**, 1 p. 154–160.

[8] Roza Y Yuanita P Saragih S Alfajri H and Saputra A, 2017 Computer-Based Media for Learning Geometry at Mathematics Class of Secondary Schools *J. Educ. Sci.*

[9] Kurniawan F, 2020 Development Of Smart Binoculars Learning For Trigonometry Materials In Middle Vocational School **4**, 1 p. 63–70.

[10] Kamber D and Takaci D, 2018 On problematic aspects in learning trigonometry *Int. J. Math. Educ. Sci. Technol.* **49**, 2 p. 161–175.

[11] Meilantifa *et al.*, 2019 Mathematical Comics on Class X Trigonometry Learning *J. Phys. Conf. Ser.* **1175**, 1.

[12] Mulyawati C *et al.*, 2017 TEACHING MEDIA DEVELOPMENT OF MATHEMATIC IN THE MATERIALS TRIGONOMETRY SUM AND TWO ANGLES DIFFERENCE BY USING GUI MATLAB **17**, 2.

[13] Hernawati K and Surjono H D, 2019 Improving trigonometry learning motivation using Geogebra-Assisted Guided Discovery Student Worksheet (GDSW) *J. Phys. Conf. Ser.* **1320**, 1.

[14] Maulyda M A Hidayanto E and Rahardjo S, 2019 Representation of Trigonometry Graph Funcsion Colage Students Using GeoGebra *Int. J. Trends Math. Educ. Res.* **2**, 4 p. 1–7.

[15] Zippert E L Eason S H Marshall S and Ramani G B, 2019 Preschool children’s math exploration during play with peers *J. Appl. Dev. Psychol.* **65**, September p. 101072.

[16] Khoiri M, 2014 Pemahaman Siswa Pada Konsep Segiempat Berdasarkan Teori van Hiele *Pros. Semin. Nas. Mat.* November p. 262–267.

[17] Roza Y, 2017 Computer-Based Media for Learning Geometry at Mathematics Class of Secondary Schools **1**, 1 p. 79–91.

[18] Baroody A J, 2017 *The Use of Concrete Experiences in Early Childhood Mathematics Instruction* 1st ed., **53** Elsevier Inc.

[19] Saputra M Abidin T F Ansari B I and Hidayat M, 2018 The feasibility of an Android-based pocketbook as mathematics learning media in senior high school in *Journal of Physics: Conference Series*.

[20] Borzekowski D L G, 2018 A quasi-experiment examining the impact of educational cartoons on Tanzanian children *J. Appl. Dev. Psychol.* **54**, March 2017 p. 53–59.

[21] Mares M L and Kretz V, 2015 *Media Effects on Children* Second Edi, **14** Elsevier.

[22] Herawati E, 2017 BELAJAR SISWA MENGGUNAKAN MEDIA PEMBELAJARAN KARTU DOMINO MATEMATIKA **1**, 1 p. 66–87.

[23] Kazanidis I Pellas N Tsinakos A and Fotaris P, 2018 instructional media design courses ? **0**, 0 p. 1–14.

[24] Pradja N S *et al.*, 2018 PENGARUH PENGGUNAAN MEDIA BAGAN TANGGA SATUAN **15**, 2.

[25] Byrnes J P and Wasik B A, 2009 Factors predictive of mathematics achievement in kindergarten, first and third grades: An opportunity-propensity analysis *Contemp. Educ. Psychol.* **34**, 2 p. 167–183.