Development of virtual reality math media in the yunior high school Indonesia-Malaysia with group investigation model

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ABSTRACT

Conventional mathematics learning is felt to be less interesting and boring for students. Students need innovative learning and make students active in learning. To improve students' understanding of learning mathematics, innovation is needed in innovative learning media. This study aims to produce a product in the form of virtual reality media in mathematics learning based on the group investigation model. This study uses the ADDIE research method with analysis, design, development, implementation, and evaluation stages. Before being tested, the media was validated by a media expert validator with a result of 86% in the "Very Good" category and a material expert with an assessment result of 94% in the "Very Good" category so that "VR Math" was declared valid. The results of the VR Math learning media trial showed that (1) the results of calculating the percentage of students' learning completeness in the experimental class were 90%, (2) the average learning outcomes of the experimental class were better than the control class, (3) there was an increase indicated by a score of N -0.76 gain in the "High" category. Based on the results of the trial, the VR Math learning media was effective for group investigation-based mathematics learning based on the effectiveness indicator, namely achieving 90% classical learning mastery, the experimental class learning outcomes were better than the control class, and there was an increase.

INTRODUCTION

The use of learning media in junior high school in mathematics lessons is currently not optimal. With technology developing rapidly, teachers must make the best use of technology to develop learning media as a way to improve students' understanding of learning, especially in mathematics. Widodo and Wahyudi (2018) agrees with Haryono (2015) which states that learning media is anything that can be used to transmit messages, can stimulate thoughts (stimuli), feelings, interests and willingness of students so that they can encourage the creation of teaching and learning processes to add new information. on students. In this research, the researcher will develop an virtual reality media based on the group investigation model. Audio-visual with VR Math media plays an important role in the educational process, especially when used by teachers and students. Audio-visual with virtual reality media provides a lot of stimulus to students, because of the audio-visual/sound-image nature. Audio-visual enriches the learning environment, fosters exploration, experimentation and discovery, and encourages students to develop conversations and express their thoughts (Sanjaya, 2010).

Based on interviews with two mathematics teachers at yunior high school SMP NASIMA Semarang, it was shown that schools had not used virtual reality media in learning mathematics, this

was because children were not used to being introduced to VR Math products in class, teachers were still limited to using PowerPoint media with three-dimensional animation, so students need to be introduced to virtual reality so that their spatial abilities and student learning motivation are increased by adventuring in cyberspace, while at one of national school in Malaysia based on interviews with teachers there it is explained that VR Math media has not yet been introduced in classroom learning, so it is necessary to make VR Math products that are updated according to the times and it is hoped that students and teachers will need mathematics learning that is more fun and enjoyable for students by surfing in virtual worlds with augmented reality and virtual worlds.

One of the advantages of VR Math is that it is quite easy to use and does not require special skills because the steps are not different from playing ordinary videos on a computer/laptop, vcd player, or dvd player in general. In addition, many interesting and funny animation options are already in the VR Math application so that users no longer need to make animations. The final result of VR Math is in the form of an interactive enough animated video with virtual reality so that it can attract students' interest to pay attention to the show (Triatmaja & Khairudin, 2018). According to Sutama et al. (2019) states that the Group Investigation learning model is group-based learning which provides opportunities for students to discuss, think critically, and can be responsible for the learning.

The use of a good learning model should be able to produce effective learning and be able to optimize students' abilities. There are various learning models that can be implemented in the 2013 curriculum learning, for example the Group Investigation (GI) learning model. The GI (Group Investigation) learning model is a cooperative learning model that requires students to be active and participate in the learning process by digging/searching for information/material to be studied independently with available materials (Indarti et al., 2018). With this process, students will learn actively, seek important information, and by itself will develop critical thinking skills. The process of building knowledge independently trains students to explore a fact, generalize and organize the ideas obtained. This will have a good impact on students' critical thinking skills. The impact of this independent search for information can be seen in the results of research conducted (Eviyanti et al., 2021). where GI (Group Investigation) was declared effective in terms of students' learning outcomes in mathematics. So the researcher concluded that the group investigation model involved students from planning, both in determining topics and ways to learn them through (Gading et al., 2017). This learning model requires students to have good skills in communicating as well as in group processing skills. Teachers need to assess students' abilities to plan lessons, choose topics, think based on questions that arise from problems (Khasanah & Setyaningsih, 2016). by using VR Math media, junior high school students become more interested in participating in learning mathematics both inside and outside the classroom

METHODS

The research and development method is a research method used to produce a particular product and test the effectiveness of the product (Sugiyono, 2013).In this study, the aim was to develop learning media in the form of VR Math material on integers in grade 7 junior high school. This learning media aims to help students who have difficulty understanding integer material in grade 7 junior high school. Based on the procedure as shown in Figure 1, this research uses the ADDIE development model which consists of five stages, namely: analysis, design, development, implementation and evaluation (Setyosari, 2010).

ADDIE development model

Analysis Stage (Analysis)

At this stage, the analysis stage (*analysis*) conducted at SMP NASIMA Semarang Indonesia and one of national schools in Malaysia which includes the following activities:
1. Analysis of the use of facilities and infrastructure in grade 7 junior high school.
2. Analysis of the learning process in grade 7 junior high school,
3. Analysis of the use of instructional media in grade 7 junior high school. All stages of the analysis were carried out to find out the needs of the two junior high schools, as well as to provide input
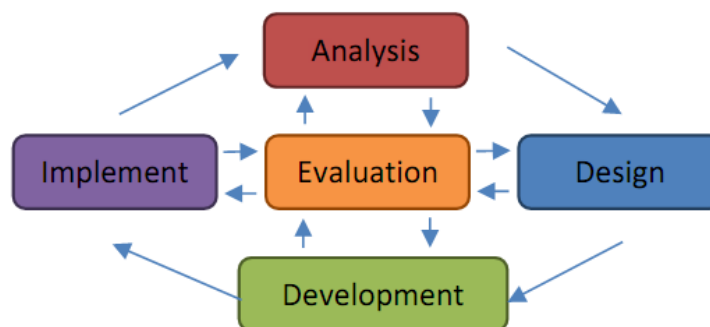
Figure 1. ADDIE Development

to researchers so they could develop media that fit the needs of the two junior high schools.

Planning (Design)

This stage is a follow-up stage of the analysis stage. At this stage the researcher carried out the design as follows:

1. Define learning media users,
2. Determine the competencies and indicators to be achieved through learning media,
3. Designing media designs that can support the achievement of competencies and indicators to be achieved,
4. Determine the level of student mastery in learning after using the media designed by the researcher. This activity aims to provide convenience to teachers in conveying information and material in the teaching and learning process.

Development

The development stage is the activity of translating design specifications into physical form (product). The product that will be made by researchers is media *VR Math*. This stage is the amalgamation of text media, media that can be manipulated and subject matter. The media that has been developed by researchers will be validated by three validators, namely material experts, media experts, and learning experts.

Implementation

This activity is an activity of implementing products that have been developed in learning to determine the effect on the quality of learning that is interesting, effective, and efficient in learning. The application of this learning media product was carried out at SMP NASIMA Semarang and one of national school in Malaysia.

Evaluation

This stage is the final stage, namely evaluating the activities carried out by researchers to determine the quality of the media products that have been developed. The evaluation stage is used to determine the feasibility of the media developed by the researcher. The data obtained at this stage is used to improve the product being developed.

Data collection technique

Media expert validation questionnaire

Media expert validation is someone who is expert and experienced in the field of learning media. Through the validation of media experts, values or input from media experts will be obtained regarding the products that the researchers have developed whether they are suitable for use or not.

Material expert validation questionnaire

Material expert validation is someone who is an expert and masters the field of material or subjects such as math teachers and mathematics education lecturers. Material experts validate the material contained in the Audiovisual Powtoon learning media based on the Group Investigation model whether it is in accordance with the concepts and competency standards or not.

Test sheet

The form of the test used in this study is a matter of description. Before the questions are tested on students, the questions must be tested first to find out the criteria for reliability, validity, difficulty level and discriminating power.

User questionnaire

The user questionnaire is filled in by students and teachers, used when testing Powtoon audiovisual media products. This questionnaire aims to find out responses about the media being developed. The following is a validation questionnaire grid from experts and student response grids.

Data analysis technique

Expert validation analysis

The percentage calculation according to Arikunto (2010) is as follows:

$$P = \frac{\sum (answer\ x\ the\ weigh\ of\ each\ choice)}{n\ x\ highest\ weight} \ x\ 100\%$$

Description:

P = Percentage of questionnaire results
$\sum$ = Amount
n = Total number of validation sheet items

The qualitative criteria of the percentage range are shown in Table 1.

Product effectiveness analysis

Clasical learning completeness test

The KBK test is used to determine the value of student learning outcomes in achieving classical mastery. One class is said to achieve classical learning mastery if in that class there are students who have completed it $\geq 85\%$.

One right party t-test

The right-sided t-test is used to determine whether the average learning outcomes of the experimental class are better than those of the control class.
Demand Sugiyono (2013). if the two variances are equal. Statistics used $\sigma_1 = \sigma_2$

$$t = \frac{x_1 - x_2}{s_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Information:
t = difference in mean results
s_1^2 = variance of the experimental group
s_2^2 = control group variance
x_1 = average value of the experimental sample
$\overline{X_2}$ = mean value of the control sample
n_1 = number of samples of the experimental group
n_2 = total sample of the control group
s_p = standard deviation

Criteria:

$$\text{Accept if } H_0\ t_{value} \leq t_{table}$$

Table 1
Percentage range and program qualitative criteria

No.	intervals	Criteria
1.	81% - 100%	Very good
2.	61% - 80%	Well
3.	41% - 60%	Enough
4.	21% - 40%	Not enough
5.	< 21%	Less Once

Table 2
Normalized gain interpretation

Normalized Gain Value	Interpretation
$-100 \leq (g) < 0,00$	There was a decline
$-100 \leq (g) < 0,00$	No increase
$(g) < 0,00$	Low
$0.30 \leq (g) < 0,70$	Currently
$0,70 \leq (g) < 1,00$	Tall

Table 3
Categories of N-Gain effectiveness interpretation

Percentage (%)	Interpretation
>76	Effective
56-75	Effective enough
40-55	Less effective
< 40	Ineffective

If the two variances are not equal, the statistic used: $\sigma_1 \neq \sigma_2$

$$t' \frac{x_1 - x_2}{\sqrt{\dfrac{s_1^2}{n_1} + \dfrac{s_2^2}{n_2}}}$$

Information:
t' = difference in mean results
s_1^2 = variance of the experimental group
s_2^2 = control group variance
x_1 = average value of the experimental sample
x_2 = average value of the control group
n_1 = number of samples of the experimental group
n_2 = total sample of the control group

Criteria : Accept H_0 if

$$-\frac{w_1 t_1 + w_2 t_2}{w_1 + w_2} < t' < \frac{w_1 t_1 + w_2 t_2}{w_1 + w_2}$$

N-gain test
    This test is used to determine the increase in students' literacy skills obtained from the results of the pre test and post test. The following is the n-gain test formula developed by Hake (Sugiyono, 2013)

$$(g) \frac{skor\ posttest - skor\ pretest}{skor\ ideal - skor\ pretest}$$

Table 4
Indicators Categories of Basic competencies and achievement

Basic competencies	Indicators of Competence Achievement
4.1 Explain and perform arithmetic operations on integers and fractions by utilizing various properties of operations.	4.1.1 find the results of addition and subtraction arithmetic operations on integers by utilizing the properties of addition and subtraction operations.
4.2 solve problems related to integer and fraction arithmetic operations	4.2.1 solving problems related to addition and subtraction operations on integers

After it is calculated using the n-gain formula, it is then interpreted in the n-gain test table which has been modified by Sundayana (2018) as shown in Table 2 and 3.

FINDINGS

In this research, virtual reality mathematics junior high school products have been produced which are adapted to the ADDIE model development research steps as follows:

Results of analysis step

The needs analysis stage aims at the extent to which learning mathematics on integer material in class VII SMP NASIMA Semarang and one of national school in Malaysia is carried out. At this stage the researcher conducted interviews with the mathematics teacher and made observations in two classes, namely class VII E and VII The interview was conducted on August 15, 2022 with a teacher of Mathematics as the subject.

Results of Curriculum Analysis, At the curriculum analysis stage, researchers conducted an analysis of various applicable curriculum tools. This analysis aims to formulate indicators and learning objectives based on core competencies and Basic Competencies that apply in SMP NASIMA Semarang. As we know in the previous stage, SMP NASIMA Semarang used the 2013 Revised 2016 curriculum, so that all curriculum tools refer to the 2013 Revised 2016 curriculum. The explanation of the formulation of indicators based on basic competence is shown in Table 4.

Results of design step

At the design stage, the framework and ideas for the creation of the Group Investigation-based VR Math were carried out. Design preparation is done so that researchers have an idea of the appearance, content and flow of the media to be made. The design of the instrument was carried out to compile a description of the media validation questionnaire and the materials that had been made. These instruments include media expert questionnaires and material experts as well as student response questionnaires to the use of media. Apart from that, at this stage the researcher also designed learning tools that would be used in research, the learning tools prepared were syllabus referring to K-13, lesson plans, grids of test questions, trial questions, and key answers to trial questions. Figure 1 shows the front view design of the VR Math.

Results of Development Step

In designing the VR Math Learning Application, the menus in the web application have also been designed so that it is clear, every function of each menu is related to the use of the application. The following are pictures of the menu display in the VR Math Learning Application as shown in Figure 2. According to (Sugiyono, 2013) validation aims to find out the weaknesses and weaknesses of the media and obtain inputs to improve the media being developed. In addition, validation is also intended to obtain an assessment of whether the media is feasible or not. The results of the material expert's assessment of learning media get the "Valid" category with an average percentage of experts obtained by 85% as well as the media expert's assessment of obtaining the "Valid" category with an average score achieved of 86%. According to Widjayanti et al (2019) a product is said to be valid if the results of the validator's assessment obtain a combined percentage of more than 60%. However, Safitri et al (2021) also said that a product is said to be valid if it obtains a minimum percentage of sufficient criteria.

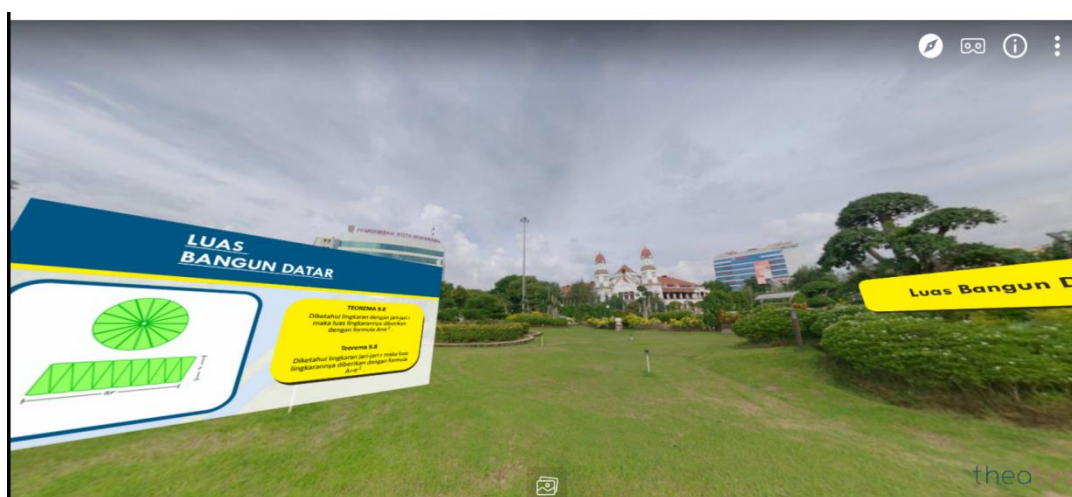**Figure 1.** Design of VR Math especially math junior high school

Figure 2. Development product VR Math

Results of implementation

Before carrying out the implementation, the researcher conducted a trial test to find out whether the question was suitable for use or not. After the questions were tested, the researcher chose two classes to be sampled in this study. The two classes will be the control class and the experimental class. A good evaluation tool can be seen from various aspects such as validity, reliability, objectivity, practicability, differentiability, level of difficulty, option effectiveness, and efficiency (Sugiyono, 2013). Previously, researchers tested the normality test, homogeneity test, and two-party t-test and obtained equal average results between the experimental class and the control class. So it can be concluded that the experimental class and the control class have equal abilities. Followed by the application of Group Investigation-based VR Math learning media in the experimental class in learning, after learning is complete a post test is carried out. From the data obtained in the field, a final analysis was carried out using the normality test, homogeneity, classical learning mastery test, one-sided t test, and the N-Gain test. From the normality test the two classes were normally distributed and in the homogeneity test it was found that the experimental class and the control class were homogeneous.

Product effectiveness can be seen from the classical learning mastery test, one-sided t test, and the N-Gain test to see the effectiveness of the media. From the results of the final analysis, it was found that the classical learning mastery in the experimental class was 90% and in the control class 53%, the classical learning mastery test was also strengthened by the left side t test and the results

obtained in the experimental class were accepted and the control class was rejected so that in the experimental class the proportion of completeness of student learning outcomes was achieved and in the control class it was not achieved, the results of the effectiveness analysis with the right-sided t test obtained results greater than ie 4.692> 1.699 so it was rejected, so it can be concluded that the learning outcomes of the experimental class were better than the control class. The results of the effectiveness analysis with the N-Gain test obtained the results of the N-Gain test. The experimental class obtained an N-Gain value of 0.76 in the "High" category and the control class obtained an N-Gain value of 0.55 in the "Medium" category. From the results of the KBK test, the right-sided t test, and the N-Gain test, it means that group investigation-based VR Math media have met the indicators so that group investigation-based VR Math media can be said to be effective. This is in accordance with research Ho rejected if $t_{value} > t_{table}$.

Zhang et al (2018) which shows that the development of VR learning media is able to increase students' understanding of self-concept in group guidance for elementary school students, then Aşiksoy and Islek (2017). Shows that with the development of VR Math media in learning Mathematics for elementary school students the students' cognitive is more improved.

Results of evaluation

The fifth stage is the evaluation stage, at this stage after learning is complete and the post test is then students are given an assessment questionnaire of group investigation-based VR Math learning media used during learning. After that the media assessment questionnaire was analyzed and the result was that the group investigation-based VR Math learning media was in the "Very Good" category. Researchers also saw that the use of group investigation-based VR Math learning media could foster student curiosity, student curiosity grew when students opened group investigation-based VR Math learning media and saw attractive media displays and varied menu displays. This is reinforced research Umar et al (2021). Which shows that the Development of product learning with group investigation can increase student literacy, then Nafsiah et al (2014) and Kusuma et al (2018). concerning the Development of VR Math Learning Media in Social Studies Subjects makes students more understanding simultaneously on material and with group investigation model make student enthusiastic about learning.

Based on the discussion above, it can be seen that group investigation-based powtoon audiovisual learning media to improve junior high school students' abilities is appropriate for use in learning activities according to media experts, material experts, and student learning outcomes. this shows that the learning outcomes of learning using VR Math learning media based on group investigation are better than learning outcomes using conventional learning.

DISCUSSION

In the analysis stage it has been shown that learning at NASIMA Middle School Semarang and one of national school in Malaysia has not used virtual reality-based renewable media in mathematics learning then children have not been accustomed to investigation-based learning in learning therefore it is necessary to carry out IT-based learning innovations and an investigation-based learning model, this is according to Neelofar et al (2022). Which shows that children in learning with an investigative model are able to reduce students' fear of trying to find the best solution then Bal et al (2022). Explains that with student learning independence, student self-confidence increases, especially in problem solving.

Then at the product design stage the VR Math learning media has used the best software in making VR Math products suitable for use, then the scope of existing material is devoted to geometry material, especially the area and volume of geometric shapes that students really need in mastering the material which so far has been felt to be very difficult to understand students, this has been confirmed Buchori et al (2017). Whereas learning media based on augmented reality and virtual reality can increase students' motivation and cognitive abilities in learning geometry both in class and outside the classroom, then Patac et al (2022). Shows that in understanding students about geometry, a nine-step approach is needed so that students really master geometry material holistically. Then Liu et al (2015). That by combining virtual reality media with e-learning really helps students because in e-learning can be accessed anytime and anywhere with virtual reality which is interesting to use in online learning.

Then at the development stage a product test was carried out by experts in their field which showed that this junior high school mathematics virtual reality product was suitable for use as a supplement in learning mathematics in class, this was explained by Potkonjak et al (2016). That virtual reality is needed to help explain the phenomena of science and technology today, especially related to abstract mathematical explanations, then Kapilan et al (2021). Explaining that during the Covid-19 pandemic, virtual reality-based virtual labs were always used in the practice of mechanics material in class, so that students really understood how to make mechanical products, then Srinivasa et al (2021) explaining that with Virtual Reality increases student knowledge and student learning independence both in the lab or outside the school lab.

Then in the implementation phase it was carried out at NASIMA Middle School Semarang and this VR Math product was introduced at one of national school in Malaysia where the two schools were very enthusiastic about using it, all students tried to use the product by exploring material virtually by practicing area and volume of geometric shapes independently so that learning outcomes and student learning motivation are better, this is according to Gorghiu et al (2009). Combining IT and chemistry learning makes it easy for students to practice it outside of school, this is practiced in chemistry learning by being given virtual reality students can study independently at home with the same good results when practicing in the school lab, then (Sunandar et al., 2020) explained that educational games based on virtual augmented reality make students enthusiastic about using their products and mastering geometric material in a fun way, then Zheng et al (2015) explains that with virtual reality, the real world can be packaged virtually by facilitating students' abstractions when using virtual reality products anywhere.

Then at the evaluation stage a post test was carried out which showed that there were differences in student learning outcomes on the area and volume of geometric shapes assisted by virtual reality mathematics media, this is in accordance with Kavanagh et al (2017). That mathematics learning which is packaged systematically with virtual reality really helps students in mastering the concept in depth, then Freina and Ott (2015). That virtual reality makes learning mathematics have artistic value, not just monotonous counting, students can have an interesting virtual adventure, then Elmqaddem (2019). explains that Augmented Reality and Virtual Reality are two things that complement each other in making it easier for students to understand material with three dimensions and augmented reality in each material so that it is very comfortable to learn the material, then Pantelidis (2020) with virtual reality makes it easier for teachers to provide training on a material with students asked to study independently of the material to be discussed at future meetings. This makes students really forced to learn more independently in understanding the subject matter.

CONCLUSIONS

For Mathematics teachers, they should use the Audiovisual Powtoon learning media with the group investigation method model in learning Mathematics subject Integer material, especially the VR Math model group investigation learning media because it has proven its effectiveness in increasing student achievement. Teachers are better able to utilize methods that are more interesting and varied, so that students are more interested and motivated to learn. For students, should be more active and participatory in the process of teaching activities in order to achieve learning objectives. For schools, these results are expected to provide input in the use of new methods in schools. For advanced researchers, it is expected to further develop various other interesting methods for research on learning language skills in the schools

ACKNOWLEDGMENT

AUTHOR'S DECLARATION

Authors' contributions	All author's contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.
Funding Statement	This research was funded by LPPM PGRI University Semarang and Research Center of Universiti Teknologi Malaysia
Availability of data and materials	All data are available from the authors.
Competing interests	The authors declare that the publishing of this paper does not involve any conflicts of interest. This work has never been published or offered for publication elsewhere, and it is completely original.

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