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"Magic Boosed" an elementary school geometry textbook with marker-based augmented reality

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Abstract

Recently media that is used on mathematic study is just board and printed book. Usually teacher uses, modelling tool to visualize study objects like geometry, but students must be in alternatively to fulfill that demand requires application which can deliver 3-dimension geometry to emphasize students understanding of volume and surface area. This research will implement based tracking marker method on textbook and develop geometry study application based on augmented reality, it is called "Magic Boosed". The existence of AR combination technology, then geometry which will be taught by teacher to elementary school student will be more interesting and make students are easier to learn shape and geometry formulas, this is evident from data analysis test on student learning improvement using kolmogorov-smirnov testing.

Keywords*: augmented reality, elementary school, geometry, marker-based tracking*

1. Introduction

Geometry is one of subject matter that is learned in mathematic. Geometry is three dimension structures which has space and limited by sides. Every type of geometry has shape, wide, and each volume. This time, media, which is used on geometry, is just board and text book then the inside and backside is unseen. Usually teacher uses modeling tools to visualize that geometry (math-props), but student must alternatively to see closely to that geometry, because it is not possible each student get all this modeling tools with the numbers of the kind of geometries. The storage to keep modeling tools and the modeling tools itself must be brought into the class it also become the obstacle itself. To fulfill that demand in line with the development of knowledge and technology, especially in education sector, using of learning media becomes more various and interactive, one of them which is popular right now is by using Augmented Reality (AR) technology.

Augmented reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are augmented by computer-generated perceptual information, ideally across multiple sensory modalities, including visual, auditory, haptic, somatosensory, and olfactory. In this way, augmented reality alters one's current perception of a real world environment, whereas virtual reality replaces the real world environment with a simulated one. Augmented Reality is related to two largely synonymous terms: mixed reality and computer-mediated reality [1-5]. Augmented reality based on tracking method it is divided into two, which are marker based tracking and marker less tracking [1, 3]. Marker based tracking used marker with shape of black and white with bold black border and white background. While marker less tracking method can be done with any shape. Marker based tracking is more suitable for use on the paper media than marker less tracking method. This method can display 3D objects right above the position of on the paper with marker and it interactive when user move or slide the paper with marker.

Augmented reality research has been done for any promotion media [6-8], education [9-11], tourism [12, 13], and others [14, 15]. Augmented reality is applied in education

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with the aim of improving the teaching and learning process. This research contributes in educational technology with an augmented reality media. Textbook is used not only as teaching matters but is also can displaying interactive 3D objects. We implemented marker based tracking method on application and geometry learning for elementary school. It's called "Magic Boosed". Marker based tracking method is very suitable applied in textbook. This marker is suitable applied to the elementary school textbook that is usually printed in black and white [9-11].

"Magic Boosed: Book Solid of Education" is like magical book it can show 3D geometry object on the paper book. This research is expected geometry application "Magic Boosed" based augmented reality with this marker-based tracking method can show 3-dimension geometry then it can add elementary student's interest and understanding which learn it. Besides developing the "Magic Boosted" application, this study tested the improvement of student learning with Kolmogorov-Smirnov [16] testing.

2. Related Works

Augmented Reality research before is done by researcher leader Andrea, explains the usage of Augmented Reality in promotion media of new student recruitment. Magnificent building which becomes infrastructure of STIMIK Widya Cipta Dharma campus shown by new student recruit through 3D visualization of campus building by PC (Personal Computer). Augmented Reality is the right solution to show 3D building through promotion brochure media [6]. Liena, et al, from Valencia University which has title Implementation of Augmented Reality in Operative Dentistry Learning is a research which test effectiveness of dentistry education practice with Augmented Reality compared with manual practice display [10]. Rohendi, et al., in their research, they developed geometry learning media based on augmented reality in android platform is like this research. The difference, it was implemented in teaching three-dimensional objects for junior high school students to find out: how is the student's response in using this new media in geometry and is this media can solve the student's difficulties in understanding geometry concept. The results showed that the use of geometry learning media based on augmented reality in android platform is able to get positive responses from the students in learning geometry concepts especially three-dimensional objects and students easier to understand concept of diagonal in geometry than before using this media. At the end of their study only measure the pleasure of using this app, but they do not measure the student learning improvement [8].

In Tekkesinoglu, et al research team, the goal of their work is to present a concept for web based Augmented Reality. They have many examples of Augmented Reality systems in different field from military applications to medical applications, from entertainment to manufacturing. In this paper they worked on how virtual environments can be combined with web based applications [11]. In Affan, et all research is to produce Augmented Reality application that could visualize information of Dieng tourism objects, as an interactive, interesting information and tourism promotional media. The user would get information about every tourist attraction in Dieng through the augmented reality application that contains many contents about the sites by scanned Natural Marker that already exist in every Dieng tourist attraction sites with their smartphone [12].

Whereas on this research, "Magic Boosed" which is build combine graphic data 3D geometry shape with marker-based tracking method. It shows cube, block, prism, pyramid, tube, cone and ball with elements, formulas, and exercises which is applied on that geometry which can be run on smartphone on android. With interesting view and shape of 3D geometry can help student understand the subject of geometry in mathematic subject on Elementary School level it also makes Elementary School student easier to study geometry everywhere because that subject is already in smartphone or tablet android application.

3. Purpose Method

This research is including on quantitative research which is quasi experiment. Review from the method, it is used Quasi Experiment research method. It is done to see the effectiveness of student learning score improvement which uses mathematical props. This testing method is chosen because research cannot control the outside variables which can

affect the experiment application and cannot control strictly the internal and external validity which happen in class in learning process. Research design which is used is Non-equivalent Control Group Design. In this design, research is finished by post-test last test which is given to both groups. Design which is used showed on Table 1. First group will use “Magic Boosed” to lean volume and surface area, and second group use primitive mathematic props.

Table 1. Non-equivalent Control Group Design

Groups	Pre-test	Treatment	Post-test
Experiment	O	X_1	P
Control	O	X_2	P

Description:
O = pre-test to know the early student skill
P = post-test to know the last student skill
X1 = Using of “Magic Boosed”
X2 = Using of primitive mathematic props

Population on this research is includes 5 classes. Sample on this research are 2 classes which are 4B and 4C which have score under the graduation standard which is 78 points. Sampling technique which is used was Purposive Sampling which is sampling technique which is done by collecting subject is not based on level, random or region but based on some purpose. On student test result uses pre-test and post-test with 10 questions. Before test it is tested to another class. This try out is done to know the test is already fulfill the good test requirement by testing the differentiator index, difficulty index, and reliability test.

- Pre-test, is test which is done before teaching and learning process using or before treatment [17]. It is to measure the student early skill on simple geometry subject. Pre-test result is done to measure homogeneity level of student skill on experiment and control classes.
- Post-test is test which is done after teaching and learning or after treatment [17]. Based on the purpose, post-test is used to know and compare the improvement of student average result on simple geometry subject [17].

Data on this research is quantitative which form is with student learning result which is served with descriptive method whereas to pull the conclusion from sample data to population is used inferential statistics [18].

- Descriptive statistics. It is used to describe data which is obtained as table, frequency distribution, deviation standard, average calculation, highest score and lowest score.
- Inferential Statistics. It is used to do hypothesis test, first it is done the test analysis requirement. Analysis requirement is requirement which is must be fulfilled for the need of hypothesis test which are normality test and two variants homogeneity test.

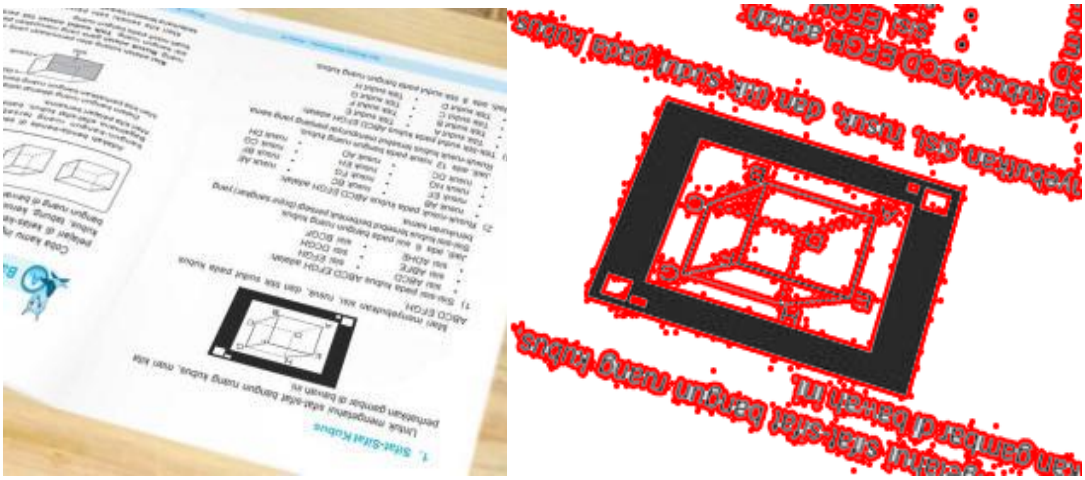
4. Results and Discussion

Augmented reality presents information in a correct real-world context. In order to do this, the system needs to know where the user is and what the user is looking at. Normally, the user explores the environment through a display that portrays the image of the camera together with augmented information. Thus, in practice, the system needs to determine the location and orientation of the camera. With a calibrated camera, the system is then able to render virtual objects in the correct place. The term tracking means calculating the relative pose (location and orientation) of a camera in real time. It is one of the fundamental components of augmented reality [19-21].

On this application of “Magic Boosed”, tracking process on textbook based on marker starts from input image stage. This stage is the stage where processor process real time frame per frame form video capture result. The next stage is image threshold, on this stage every video frame has thresholding process until produce black and white image. This stage aims to recognize square shape and marker pattern from video which is captured [22, 23]. Tracking process is marker detection, which consists of four phases, which are: contours extraction,

corner detection, pattern normalization and template matching. Process of contours extraction and corner detection shown on Figure 1 (a).

Contours extraction process and corner detection process and corner detection process uses black and white image which is gotten from second stage to get coordinate from four sides and four marker corner spots, shown on Figure 1 (b). Next stage on marker detection process is pattern normalization and template matching shown on Figure 2. Pattern normalization process which aims to normalize marker shape then template matching process can be done correctly.



(a) (b)

Figure 1. Image threshold stage (a) contours extraction and marker detection stage (b) find black marker

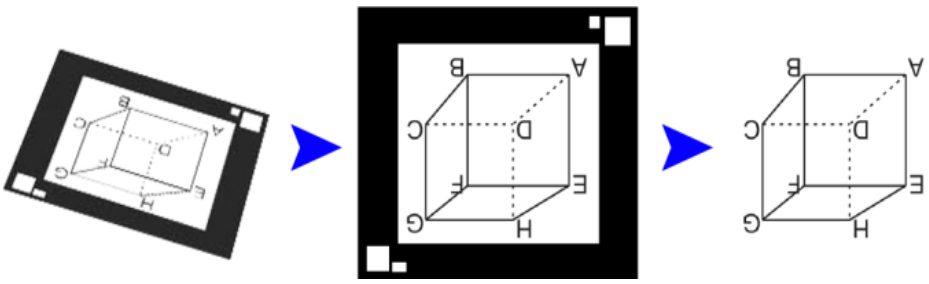
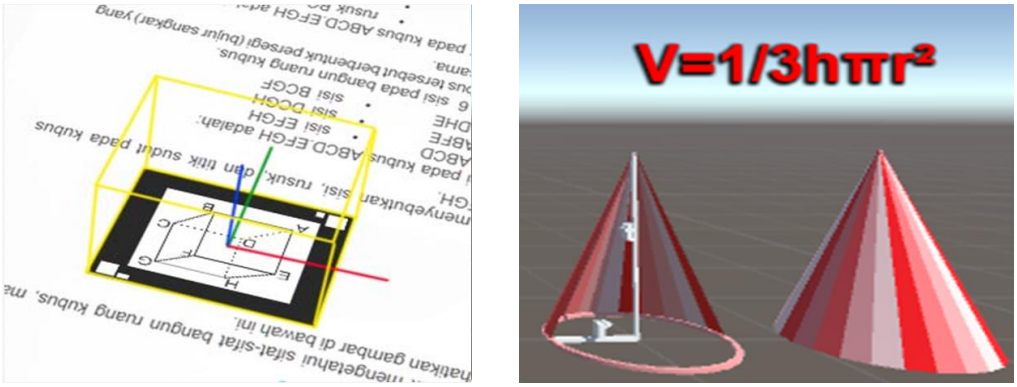


Figure 2. Pattern normalization and template matching

Last stage is pose stage and position estimation. This stage is responsible in virtual object above the marker. This stage is relation between three coordinates hold important roles, which is coordinate from tool's view (observed screen coordinates). Coordinate system shown on Figure 3 (a). On this stage is done transformation process which is needed to get relative camera position on marker in coordinate from video captured. "Magic Boosed" is design with as interesting as possible so elementary school student did not feel bored in teaching and learning process in the class. Geometry of 3-dimension object here has solid object view and formulas which are occurred to the object. Solid object is a perfect view of geometry shape. Object frame is view to show inside the object and it is given elements explanation which consist on that object like height, length, wide, side, radius, and base. Formulas which are validated to that object are showed in the top, formulas which are showed like surface's wide and volume shown on Figure 3 (b).



(a) (b)

Figure 3. Place virtual object (a) marker coordinate system and (b) 3D virtual of cone object

Textbook based on AR is also designed as interesting as possible so students happy when they use it. Figure 4 shows, every page of “Magic Boosed” textbook there are markers which implemented marker-based tracking method. If student directs camera to that marker, there will be 3D object of geometry which is suitable with subject matter on that page it shown on Figure 4.

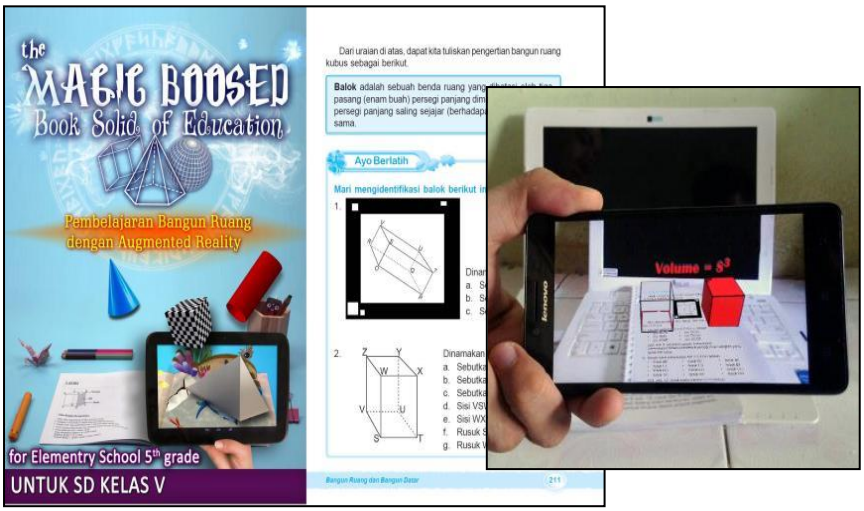


Figure 4. 3D virtual cube apper on “Magic Boosed” textbook

4.1. System Evaluations

Beta testing involves sending the product to beta test sites outside the testing environment for real world exposure. Testing is done by simple questionnaire which is filled by teacher and students of elementary school SDN 007 Samarinda. On this research, testing is done to 2 teachers and 8 students, where it is served on 5 questions which referred to learning content and “Magic Boosed” visual application design. Questionnaire question are made as simple as possible so students can fill it easily. From beta test result on Table 2, it can be considered the measure for “poor” answer has 1 point, for answer “fair” with 2 points, and answer “good” with 3 points. Then can be taken counting percentage average of respondent value.

$$\underline{X} = \frac{33 \times 3 + 11 \times 2 + 6 \times 1}{50 \times 3} \times 100\% = 84.6\% \quad (1)$$

Table 2. Result of Beta Testing

Question	Respondent's Questions			Total respondents
	Good	Fair	Poor	
How is the design from textbook?	6	4	0	10
How is the interface view of this learning application?	7	1	2	10
How is the learning content?	7	2	1	10
How is the 3D object shape which is showed?	5	4	1	10
How is the compatibility of this application with your smartphone?	8	0	2	10
Total Answer	33	11	6	50

Based on that percentage on (1) which is gotten is 84.6%, then this learning application of geometry is accepted, because percentage value which is gotten, above the minimum percentage which is 50% (above enough/fair), and close to 100% (Very good). After some test are done.

4.2. Student Learning Evaluation

Post-test is done to see the effectiveness the improvement of quantifying students learning who uses this "Magic Boosed" application compared with students who just use primitive mathematical props. Sampling technique which is used is purposive sampling. Control class and experiment class is consider based on daily examination which was given. Class which will be sample is class which has average score is not far from average score. Average score which is obtained for 4B is 51.17 whereas average score which is obtained for 4C is 50.80. 4C becomes experiment class where 4C which uses AR Application of geometry and control which is 4B uses ordinary mathematical props. Subject matter which is used on this research is simple geometry which is done on 2 meetings. This research uses instrument in form of knowledge test, before research instrument is used, the first it is done the try out the pre-test and post-test on another class which is not include on class which is become sample on this research. On pre-test and post-test each consist of 10 multiple choice questions.

4.1.1. Descriptive Statistic

a. Pre-test

Based on research result which is given the learning treatment by using "Magic Boosed" application on experiment class (4C) and mathematical props on control class (4B) shown on Table 3. Based on Table 3, shown that average pre-test score before it is given the treatment with "Magic Boosed" application on experiment class (4C) is 41.969 with highest score 59 and lowest score is 29 and in control class (4B) use math-props has average is 41.875 with highest score is 63 and lowest score is 29.

b. Post-test

Based on research which is given learning experiment by using "Magic Boosed" application on experiment class (4C) and math-props on control class (4B) shown on Table 4. Based on Table 4, shown average of post-test after it is given the learning treatment using "Magic Boosed" application on experiment class (4C) is 87.46 with highest score 98 and lowest score is 70 and on control class (4B) uses math-props has average is 83.469 with highest score is 96 and lowest score is 70.

Table 3. Data of Pre-test

Basic Stats	Experiment	Control
Max	59	63
Min	29	29
Mean	41.969	41.875
Std. deviation	7.258	8.669

Table 4. Data of Post-test

Basic Stats	Experiment	Control
Max	98	96
Min	70	70
Mean	87.46	83.469
Std. deviation	6.608	8.112

4.1.2. Inferential Statistic

a. Pre-test

Normality test is used to know data is distributed normal or not by using Kolmogorov–Smirnov test, the statistic quantifies a distance between the empirical distribution function of the sample and the cumulative distribution function of the reference distribution, or between the empirical distribution functions of two samples [24, 25]. Based on test, experiment table it is obtained sig (P)=0.114 and control class sig (P)=0.178 with comparing score α=0.05

then it is obtained experiment class sig (P)=0.114>0.005 and control class sig (P)=0.178>0.05. Thus, H_0 is accepted then can be concluded both of data distributed normal and it shown on Table 5.

Table 5. Normalization Testing of Pre-test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Experiment	.140	32	.114	.945	32	.106
Control	.131	32	.178	.949	32	.132

By using F-test it will be known sample which is used come from homogeneous variation or heterogenous. Based on calculation result it is obtained F_{value} is 1.427 with $F_{table}=F_{(0.05)(31.31)\ os}$ 1.84. It shows that $F_{value}>F_{table}$ are 1.427<1.84 then H_0 is accepted means sample second variant is come from homogen variant. By using t-test it will be known whether there is a difference of early skill between control class and experiment class. Based calculation result it is obtained t_{value} is 0.047 with t_{table} 1.697. It shows score of sig two-tailed is 0.963 with significance is 0.05, which is 0.963>0.05 then H_0 is accepted means there is no differences of early skill between experiment class and control class.

b. Post-test

Normality test is used to know data distributes normal or not by using Kolmogorov-Simonov test. Based on test, class experiment table is obtained sig(P)=0.082 and control class sig(P)=0.140 by comparing score α=0.05 then it is obtained data from experiment class is sig(P)=0.082>0.05 and control class is sig(P)=0.140>0.05. Then H_0 is accepted then can be concluded that both data distribute normal. It shown on Table 6.

Table 6. Normalization Testing of Post-test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Experiment	.146	32	.082	.954	32	.192
Control	.136	32	.140	.954	32	.051

By using F-test it will be known sample which is used from homogeneous variant or heterogenous. Based on calculation it is obtained F_{value} is 1.507 with $F_{table} = F_{(0.05)(31.31)}$ 1.84. It shows that $F_{value}<F_{table}$ are 1.507<1.84 then H_0 is accepted meant sample second variant comes from homogeneous variant. By using t-test it will be known whether there is or there is no difference of early skill between control class and experiment class. Because data is coming from homogeneous variant, based on calculation result it is obtained t_{value} 2.163 with t_{table} 1.697 or comparing score sig two-tailed 0.034 with significance degree 0.05, are 0.034<0.05 then H_0 is rejected and Hα is accepted meant there is difference between usage of AR media application of geometry with math-props with student learning result, where experiment class (4C) is better than control class (4B). Then it can be concluded that there is difference between the usages of "Magic Boosed" application and primitive math-props with student learning result on simple geometry subject on 4th grade of elementary school.

5. Conclusion

From AR technology is correct solution as replacement of teacher's modelling tools (math-props) for volume and surface area mastery on elementary school. Marker-based tracking is method which is applied on book based AR to show virtual object of geometry 3 dimensionally on textbook. "Magic Boosed" application can be used by teacher and students wherever and whenever through smartphone media.

From testing result is concluded this application is responded positively by elementary school teacher and student, it can be concluded based on data analysis test on student learning improvement test it is obtained t_{value} 2.163 and t_{table} 1.696. Decision taking if $t_{value}> t_{table}$ are 2.163>1.697 then it can be concluded that there is differences of student learning result between usage of "Magic Boosed" and ordinary math-props on basic geometry mastery. Where

student learning result on basic geometry for student who uses “Magic Boosed” is more effective. It shown on post-test average score from control class and experiment class are different, experiment class with score 87.47 and control class with score 83.4.

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