

The Development of Augmented Reality Media for Physics Subject in Learning Optical Devices Material at SMK Multimedia

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Abstract-*This study aims to produce the feasible and effective Augmented Reality media as an effort for problem solving in learning Physics especially in the topic of optical devices. This is due to the teaching-learning process that is dominated by teacher center, while the material for optical devices needs to be visualized with concrete pictures. It is expected that this media can be useful effectively in order to achieve the learning objectives optimally. The development model used in this study was Research and Development (R&D) applying 10 stages of development, and it produced a product in the form of Augmented Reality, in which the subjects were tenth grade students of SMK Multimedia Surabaya. The data collection techniques used were interview, questionnaire, and test, while the data analysis techniques were done by analyzing the data of questionnaire with percentage formula and analyzing the data of test with the formula of t-test. Based on the result of reliability test from the material expert, it gained the percentage of 100% and the result of reliability test from media expert gained the percentage of 100%. The data from individual trial results scored 97%, the data from small group trial scored 98%, and the data from large group trial scored 100%. Therefore, Augmented Reality media were admitted as feasible media that can be used in learning process. The result of t-test gained from pre-test and post-test showed the calculated result which was greater than t_{table} ($2.81 > 1.988$). Thus, it can be concluded that Augmented Reality is an effective medium to be used for learning process.*

Keywords: *Development, Augmented Reality Media*

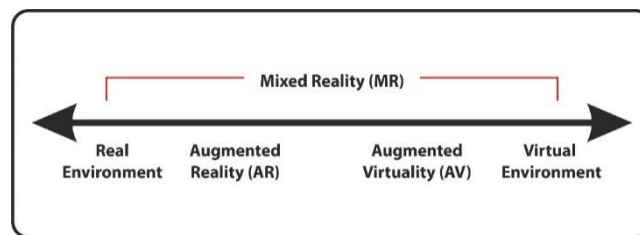
I. INTRODUCTION

It has been entering the era of industry revolution 5.0 where the advancement has begun to appear. Industry 5.0 is the industry that links the technology of automation and cyber. It appears that people are interesting at the development of computer and internet which bring big impact for the development of education nowadays. From the preliminary studies through interview with the Physics teachers, the real condition of learning process which was found, such as 1) Students had difficulties in comprehending the material of optical devices in Physics subject because the learning activity which was dominated by teacher center, and the teacher itself only discussed based on the material used. It made the students were less able to present the concept that was meant. They needs concept visualization to be concrete form. It was proved by tenth grade students' daily test of multimedia class, in which the score of 30 students out of 40 students was under the standard of minimum completeness with an average of 60, while the standard of minimum completeness which has been set was 75; 2) There was no laboratory for students practice; 3) The less time allocation in activity lesson due to the material charged for the students to be completed was a lot; 4) The teachers applied the media of *OHP* and power point infrequently. Based on those real conditions in the learning process, the development of learning media that is suitable to solve those problems is needed. Media have an important role in any circumstances of teaching-learning process. According to Yuen (2011), Augmented Reality refers to the wide range of technology projecting computer displays which are able to product text, images, and videos in users' perception about the real world. Wang (2011:49) defined that Augmented Reality allows users to work in the real world while visual computers receive additions that are generated or used to support the existing tasks. Ivanova (2011:176) stated that Augmented Reality is a technology that uses computer vision methods by combining objects or virtual environment that are generated from computers with real objects or environments, to enhance or add information about what the users can see. Moreover, Augmented Reality media are breakthrough and innovation in multimedia and image processing which is being developed. This technology is able to lift up a previously flat or two-dimensional object, as if it were real, united with the actual environment (Arifitama, 2015). Further, according to Ronald T Azuma (in Arifianto, 2017) who had conducted a research entitled "A Survey of Augmented Reality" defined Augmented Reality as a variation of Virtual Environment or it is well known as Virtual Reality. The use of Virtual Reality technology placed the users into virtual scope, thus, the users felt the sensation of entering to the application environment. Meanwhile, in the same time, Augmented Reality

technology is able to add the reality in the real world with the elements of the virtual objects, where the wall boundaries between the real world and cyberspace seem nonexistent. Augmented Reality is an application that can be installed for smartphone, so that it can be learnt not only in the classroom when the teaching-learning process is conducted, but also in the outside and anytime without being bound by the time. Augmented Reality media developed are an Augmented Reality media with the type of vision based, in the form of marker detection by utilizing the camera of smartphone. After the marker was detected by the camera, then, the virtual information will be processed into three-dimensional object displayed through the smartphone screen.

As stated by Newby in Kristanto (2011), learning media is anything able to carry the messages in order to achieve learning objectives. National Education Association in Kristanto (2010) explained that media are part of an object which can be seen, heard, manipulated, and discussed which is completed by supporting instruments. The existence of learning media can be utilized by teachers to support the learning activity. According Kristanto (2016:4), learning media is anything used to deliver messages, thus, it is able to stimulate students' attention, interest, thought, and feeling in learning activity to achieve the learning goals. Kristanto (2018) also stated that learning media is anything used to deliver messages in order to achieve the learning objectives that have been formulated. Learning media is anything used to deliver messages which are able to stimulate students' attention, thought, interest, and feeling in the learning process to achieve the learning goals which have been determined (Kristanto, 2017). Therefore, learning media is helpful to make the students get easier to comprehend the learning materials. The stimulation produced by learning media makes the students think actively in learning material that is delivered, thus, the learning objectives can be achieved.

According to Mustaji (2013), in general, media have some advantages, such as: Clarifying the message of presentation, so it is not too verbal; enlarging students attention, increasing the excitement of learning, increasing more direct interactions among students, environment, and reality; laying out the important foundations for the development of learning, so the lessons become more solid; providing the real experience so it can foster self-employment activities among students according to their abilities and interests; fostering regular and continuous thinking, it is mainly found in the living picture; overcoming the limitations of space, time and sense power.



Picture 1. Mixed Reality (Milgram and Kishino, 1994:283)

Milgram and Kishino (1994) classified 4 kinds of environment, such as real environment, augmented reality, augmented virtuality, and virtual environment. In the left end, there is real environment, in which the environment can be felt as real. Whereas, the right end is virtual environment, in which all information felt by the users is environment in computer produced and it is not related towards the location, object, or activities in the real world. Between these environments, there are two supplementary environments. First, augmented reality, in which it works by taking the real world as the background, also inserting the content produced by the computer. Second, virtual reality, in which the environment is completely simulated by technology. Therefore, as the development of technology, so it is possible that virtual and real elements are divided into compound of reality environment which is more complicated to be distinguished. Augmented reality and virtual reality are interactive, immersive, and cover the sensitivity of information.

There are four stages of Augmented Reality system process according to Alkhamisi (2013), these are: 1) Scene Capture; 2) Scene Identification; 3) Scene Processing; 4) Visualization Scene. Carmingniani and Furht (2011) divided Augmented Reality into five categories: fixed indoor systems, fixed outdoor systems, mobile indoor systems, mobile outdoor systems, and mobile indoor and outdoor systems.

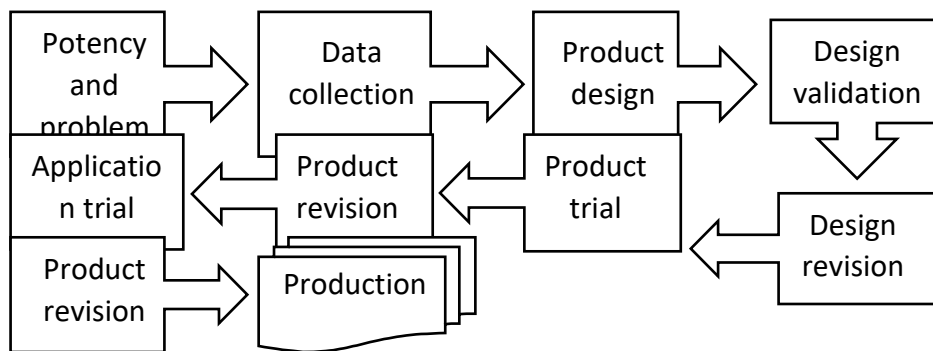
There are two types of Augmented Reality provided as media for teaching process as stated by Dunleavy and Dede in Spector, J. M., Merrill, M. D., Elen, J., & Bishop, M (2014), these are (1) location-based and (2) vision-based. Location-based Augmented Reality provides digital media so the users can move into the real environment by using smartphone which is completed by GPS or other similar tools. Whereas, vision-based Augmented Reality provides media for the students after they shot a certain object through their mobile camera.

This developed Augmented Reality media are type of vision-based by using detector on the marker. The marker used as an application for the appearance of predetermined objects is applied by scanning using a camera on the smartphone. After the marker is detected, 3-dimensional object visual information will be processed on the form of an optical device displayed on the smartphone screen. Therefore, Augmented Reality covers some elements, as mentioned by Guimaraes and Martins (2014), these are 1) System status visibility; 2) In accordance between system and real world; 3) User control and freedom; 4) Consistency and standard; 5) Error prevention; 6) Recognition rather than memory; 7) Flexibility and efficiency use; 8) Aesthetic and minimalism design; 9) Helping out the users to recognize, diagnose, and recover errors; 10) Assistance and documentation.

II. METHOD

A. Development Model

According Sugiyono (2015), Research and Development (R&D) consists of 10 development stages as follows.



Picture 2. Research and Development (R&D) (Sugiyono, 2015)

1) Potency and problem are held to investigate the problems in learning process; 2) data collection aims to look for the real data from the teachers; 3) product design is conducted to develop the learning media; 4) design validation is used to validity the learning media that has been developed; 5) design revision aims to revise the results of design validation; 6) product trial is run for the students; 7) product revision is implemented if there is a suggestion from the students; 8) application trial is run for all of the students; 9) product revision is set again if there is still a suggestion from the students; 10) production is the last stage done by constructing the media as many as the number of students.

B. Research Subject

Product trial is run in order to know whether the product produced has been feasible to be used or not. Besides, it aims to know how far the product produced is able to attain the target, goal, and perfection of development. The subject for product trial consists of two material experts, two media experts, and 40 students as the product target.

C. Research Design

This study used the model of control group pre-test and post-test. There were 2 classes divided into control class and experimental class.

E	O ₁	X	O ₂
K	O ₃	X	O ₄

Notes:

E: experimental class/group

K: control class/group

O₁: pre-test of experimental group

O₂: post-test of experimental group

X: treatment given in the class. In experimental class, treatment is given by using Augmented Reality media. Whereas, in control class, treatment is given using OHP media from the teacher.

O₃: pre-test of control group

O₄: post-test of control group

(Arikunto, 2013)

D. Research Instrument

The instruments of this study were questionnaire and test. The questionnaire is used to explore the feasibility of the media, while the test is used to explore the effectiveness of the media.

E. Data Analysis

The type of data of this study is qualitative and quantitative data. The qualitative data were in the form of suggestion and response gained from the validity result by the experts of learning design, material, and media, so those were used to revise the Augmented Reality media. Whereas, the quantitative data were gained from the result of test that was held for the tenth grade students of multimedia.

1. The Analysis of Questionnaire

The result of questionnaire in this study was analyzed by using the formula:

$$P = \frac{f}{N} \times 100\%$$

Notes:

- P = percentage grade
 - f = frequency of good agreement
 - N = number of respondents
- (Arikunto, 2013:54)

2. Validity and Reliability Test

The validity and reliability test were analyzed by using the formula:

$$r_{pbis} = \frac{M_p - M_t}{S_t} \sqrt{\frac{p}{q}}$$

Notes:

- r_{pbis} = correlation coefficient of biserial point
 - M_p = mean score of subjects who answered correctly the items sought correlation with the test
 - M_t = mean total score (the average score of all test takers)
 - S_t = standard deviation of score total
 - p = proportion of subjects who correctly answered the items
 - q = 1 - p
- (Arikunto, 2013:326)

$$r_{11} = \frac{2x r_{1/2 1/2}}{(1 + r_{1/2 1/2})}$$

Notes:

- r_{11} = instrument reliability
 - $r_{1/2 1/2}$ = rxy which is mentioned as the correlation between two instrument sections
- (Arikunto, 2013:223)

3. Normality and Homogeneity Test

Normality and homogeneity test were done as the requirement for conducting T-test. These were analyzed by using the formula:

$$\chi^2 = \sum \frac{(f_o - f_h)^2}{f_h}$$

Notes:

- χ^2 = Chi-square value
 - f_o = observed frequency (empirical frequency)
 - f_h = expected frequency (certain frequency)
- (Arikunto, 2013:333)

$$F = \frac{\text{the highest variation}}{\text{the lowest variation}}$$

(Sugiyono, 2013:276)

This F test has a significance level of 5%. Variants can be concluded as homogeneous if the results of homogeneity test shows the criterion of $F_{count} > F_{table}$.

4. The Analysis of Test

The results of the test were analyzed by using the formula:

$$t = \frac{M_x - M_y}{\sqrt{\left(\frac{\sum x^2 + \sum y^2}{N_x + N_y - 2}\right) \left(\frac{1}{N_x} + \frac{1}{N_y}\right)}}$$

Notes:

M = mean score of each group

N = number of subject

x = deviation of each value x_2 and x_1

y = deviation of each value y_2 and y_1

(Arinkunto, 2013:354)

III. RESULT AND DISCUSSION

A. The Result of Product Development

1. Potency and Problem

After doing a preliminary interview with Physics subject teachers about the optical devices, it was found problems in the students' learning process. The students have not achieve yet the material of optical devices like describing the concept, then, applied it in the real form. These problem came from the learning activity which was dominated by teacher enter, and also the supporting media were not enough.

2. Data Collection

The data were collected through interview with Physics subject teachers, and documentation, such as syllabus, lesson plan, and the results of students' achievement in learning activity.

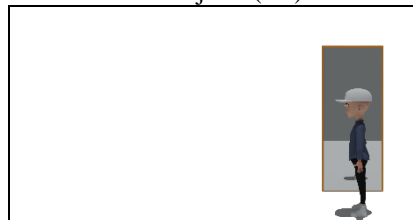
3. Product Design

a. Product design of material

Product design of material contained the design of material made based on learning objectives that would be achieved. It was presented in the form of learning media. The material items were formulated by the material expert, to know the contents of the media which was developed.

b. Product design of media

1) Design of Three-Dimensional Objects (3D)



Picture 4. Model of Three-Dimensional Object

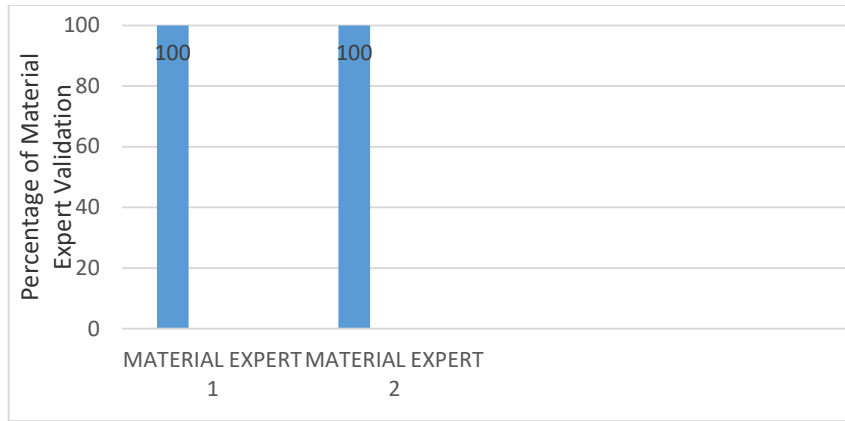
2) Design of Augmented Reality Application



Picture 5. Augmented Reality Application

4. Design Validation

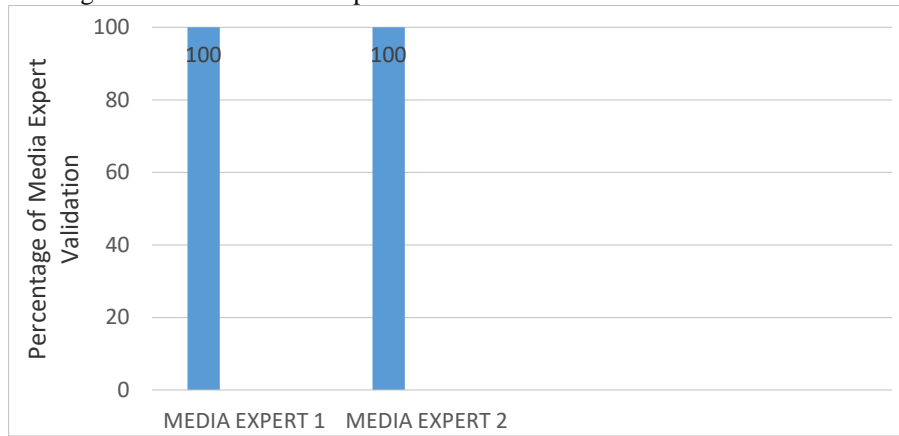
a. Design validation of material expert



Picture 6. Percentage of material expert validation

Based on the result of material validation that was done by material expert, the percentage gained was 100%. According to Arikunto (2013), this percentage was included into *excellent* category.

b. Design validation of media expert



Picture 7. Percentage of media expert validation

Based on the result of media validation that was done by media expert, the percentage gained was 100%. According to Arikunto (2013), this percentage was included into *excellent* category.

5. Design Revision

Table 1. Design revision of material expert

No.	Review	Revision
1.	It needs to be added an example of flat mirror	It has been already added an example of flat mirror

Table 2. Design revision of media expert

No.	Review	Revision
1.	The symbol is confusing that is similar with button, it can make the users have wrong perception	The symbol has been already revised as a button

6. Product Trial

a. Individual trial

Individual trial was conducted with 2 subjects chosen randomly. From this individual trial, the result of questionnaire data showed the percentage of 97%. According to Arikunto (2013), this percentage was included into *excellent* category.

b. Small group trial

Small group trial was conducted with 10 subjects chosen randomly. From this small group trial, the result of questionnaire data showed the percentage of 98%. According to Arikunto (2013), this percentage was included into *excellent* category.

7. Product Revision

After conducting individual and small group trial, the students did not give any suggestions. Therefore, there was no revision in this stage.

8. Application Trial

The application trial of Augmented Reality was run towards a big group trial, which contained 40 students from the tenth grade of multimedia. The data analysis of questionnaire from this big group trial showed the percentage of 100%. According to Arikunto (2013), this percentage was included into *excellent* category.

9. Product Revision

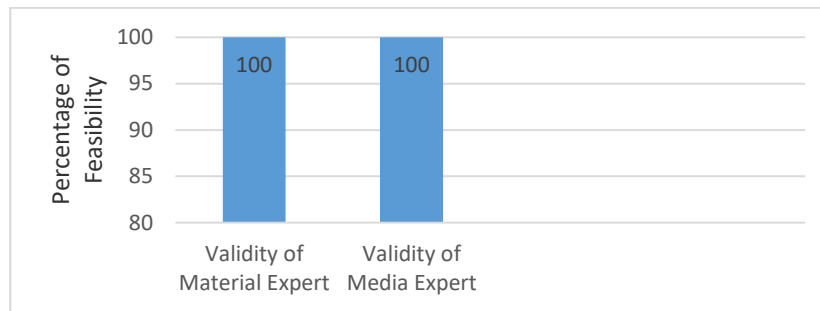
After conducting some trials, there was no suggestion from the students. Thus, there was no revision which needed to do.

10. Production

On this stage, the Augmented Reality media were only produced as many as the number of students in tenth grade of multimedia.

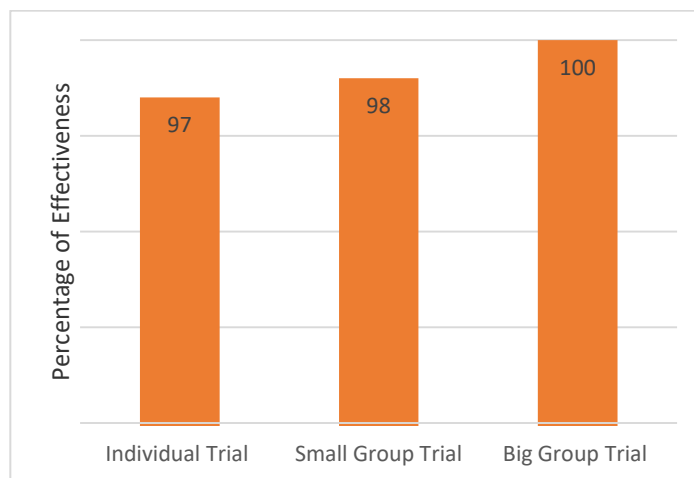
B. Discussion

This development study was produced media in the form of Augmented Reality which were used to solve the problems in learning Physics about optical devices on tenth grade of multimedia. This media development had passed some trial stages and it was declared that that use of Augmented Reality media have been feasible and effective learning Physics subject about optical devices for tenth grade of multimedia. Here, the results of discussion about this development study are elaborated.



Picture 8. Percentage of feasibility

Based on some aspects, the percentage of data gained from the validity of material expert was 95% (excellent). Then, based on some aspects, the percentage of data gained from the validity of media expert was 100% (excellent).



Picture 9. Percentage of Effectiveness

The data gained from individual trial based on all aspects of questionnaire earned the percentage of 97% (excellent). The data gained from small group trial based on all aspects of questionnaire earned the

percentage of 98% (excellent). The data gained from big group trial based on all aspects of questionnaire earned the percentage of 100% (excellent).

Based on the table 3 below, the validity test of 20 items had correlation with r_{table} 0.344 and N 33 in the significance level of 50%. Thus, the conclusion stated that 20 items were valid. The result of reliability test of the items got r_{table} 0,667. It was consulted with the significance level of 5% and N 30, so the r_{table} 0,344 and r_{count} higher than r_{table} ($0.667 > 0.344$). It was admitted that the 20 items were reliable.

Based on the result of normality test from pre-test and post-test that had been conducted in control and experimental class, the result of r_{count} correlated to the r_{table} was 9,488. The pre-test data of control group showed that $r_{count} < r_{table}$ ($7.21 < 9.488$) and the post-test data of control group showed that $r_{count} < r_{table}$ ($7.47 < 9.48$). Thus, it can be concluded that the pre-test and post-test data of control group were normally distributed. Whereas, the pre-test data of experimental group showed that $r_{count} < r_{table}$ ($6.4 < 9.488$) and the post-test data of control group showed that $r_{count} < r_{table}$ ($9.14 < 9.48$). Therefore, it can be admitted that the pre-test and post-test data of control group were normally distributed.

Table 3. Validity of Items

Number of Item	Results of Count Correlation (r_{count})	Result of Determination Correlation (r_{table})	Notes
1	0.365554	0.344	VALID
2	0.352811	0.344	VALID
3	0.365787	0.344	VALID
4	0.370662	0.344	VALID
5	0.352811	0.344	VALID
6	0.501252	0.344	VALID
7	0.467801	0.344	VALID
8	0.506601	0.344	VALID
9	0.382479	0.344	VALID
10	0.368463	0.344	VALID
11	0.591355	0.344	VALID
12	0.515972	0.344	VALID
13	0.431929	0.344	VALID
14	0.384175	0.344	VALID
15	0.388619	0.344	VALID
16	0.780465	0.344	VALID
17	0.400379	0.344	VALID
18	0.384175	0.344	VALID
19	0.399390	0.344	VALID
20	0.399390	0.344	VALID

Based on the result of homogeneity from pre-test and post-test data that had been conducted in control and experimental class, the result of f_{count} correlated to the f_{table} with the numerator dk $k-1 = 2-1 = 1$ and the denominator dk $n-k = 36-2 = 34$ with a significance level of 5%, so the f_{table} was 4.13. Then, it showed that f_{count} of pre-test was 1.18, so that $f_{count} < f_{table}$ ($1.18 < 4.13$). It was admitted that the data of pre-test from control and experimental group were homogeneous. Whereas, based on the data of post-test, it showed that the f_{count} was 1.588, so that $f_{count} < f_{table}$ ($1.588 < 4.13$). It was admitted that the data of post-test from control and experimental group were homogeneous.

The results of tests that were conducted in control and experimental class were calculated based on pre-test and post-test items. After doing calculation using the t-test formula of, the result showed that t_{count} was 2.81. Then, it was consulted using the table of t-test distribution with a level significance of 5% and the degree of division (db) = $(N1+N2)-2$. Thus, the value of db $(36+36)-2 = 70$, so the value of t_{table} was 1.988 with $t_{count} > t_{table}$ ($2.81 > 1.98$). Thus, it was admitted that Augmented Reality media are effective to be used in the learning process.

However, the advantages and constraints of Augmented Reality that had been developed were found, as follows. The advantages of Augmented Reality:

1. Interactive
2. Easy to use
3. Displaying 3-dimensional objects as the implementation of the real objects

4. The production did not cost a lot of money
 5. Effective to use in learning process
- The constraints of Augmented Reality:
1. Sensitive to the interaction of light and the changes of perspective
 2. Requiring a large capacity of memory for its production

IV. CONCLUSION

Based on the data that had been analyzed and discussed, the conclusions are:

1. After conducting the validity done by material expert and media expert, individual trial, small group trial, and big group trial, it can be concluded that Augmented Reality media are feasible to use for the learning process in Physics subject about optical devices.
2. After conducting the pre-test and post-test in control and experimental group, it can be concluded that Augmented Reality media are effective to use for the learning process in Physics subject about optical devices.

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