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Development of Smart Content Model-based Augmented Reality to Support Smart Learning

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ABSTRACT Augmented Reality (AR) is an optical technology that combines virtual objects or worlds into real worlds like in real time and increases user perceptions and interactions with the real world. Information conveyed by virtual objects helps users carry out activities (tasks) in the real world. The convenience offered makes AR technology can be used for various fields, including education, such as the development of materials or learning media. Augmented reality in its development is more comfortable, cheaper, and can be widely implemented in various multimedia needs. This research is a study of the development of multimedia based on augmented reality to produce dynamic learning materials or media in supporting the concept of smart learning. This research provides multimedia models of mathematics for circles, ellipses, parabola, and hyperbole based on augmented reality to create more dynamic learning as smart learning. Multimedia is produced according to operational standards and meets content standards based on media experts, content, and users. Multimedia-based augmented reality math is easy to operate, helps, and increases understanding and increases student motivation.

Keywords Augmented Reality, Multimedia Learning, Smart Learning

1. INTRODUCTION

Along with the current technological developments, the learning media always follow the progress of existing technology (Reisse, Heider, Giersich, & Kirste, 2008). The oldest technology utilized in the learning process is printing that works on the basis of mechanical principles, then audio-visual technology that combines mechanical and electronic inventions for teaching purposes, the latest emerging technology is the microprocessor technology that spawned the use of computers and interactive activities (Reisse, Heider, Giersich, & Kirste, 2008). Based on these technological developments, the teaching media is divided into four parts, namely: (1) Media resulting from printing technology, (2) Media resulting from audio-visual technology, (3) Media result of computer-based technology, (4) Media combined print technology and computers (Dekdouk, 2012).

Referring to the classification of learning media was born a combined learning media of print and computer technology known as AR (Augmented Reality) an optical technology that combines the object or virtual world into the real-world view in real time. Also, Augmented Reality improves perception and interaction of users with the real world. The virtual object displays information that the user can not directly detect with his senses. The information presented by the virtual object helps the user perform real-world activities/tasks (Azuma, 1997). AR is one of the most exciting technologies of interest; AR presents an immersive level in which none of the virtual tools can do it. The convenience offered makes AR technology usable to various fields, such as military, medicine, education, industrial engineering, to entertainment.

There are many learning models, based on smartphone technology that need to be supported with more real and dynamic content, especially the content aspect which is one of the characteristics of smart learning (Di, Gang, & Juhong, 2008). One of the dynamic content can be developed with AR technology, making learning more dynamic and exciting.

The tendency of learning that is less attractive is one of them due to the use of even static media using technology. The use of information and communication technology

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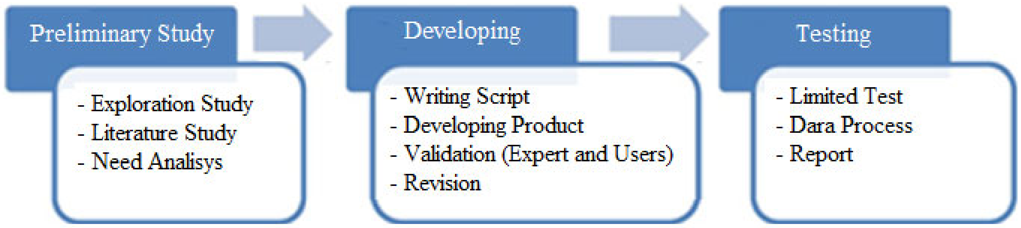

Figure 1 Research procedure

based multimedia learning is quite lively, but the application of AR technology is still low (Dekdouk, 2012).

For content that involves multiple dimensional objects, AR much helps build object abstractions for students' understanding. The idea of the concept of area and space has severe problems in mathematical content such as circles, ellipses, parabola, and hyperbole. Based on the above problems, this research examines the development of learning media using augmented reality technology for learning mathematical material circles, ellipses, parabola, and hyperbole. The main problem of research is: "How to Develop Multimedia Based On Augmented Reality To Support Smart Learning." From the formulation of the main problem, the researcher divides the research question into small points as follows: (a) How to design and develop learning multimedia based on augmented reality? (b) How is the feasibility of learning multimedia based on augmented reality developed for a limited trial? (c) The primary purpose of this research is the development of multimedia-based Augmented Reality for student learning activities. The specific objectives are: (a) The acquisition of multimedia learning model based augmented reality? (b) Knowing the feasibility of multimedia learning model based augmented reality developed before being tested in a limited way.

2. METHOD

The main objective of this research is to develop augmented reality-based media to support smart learning for students of junior high school. In general, the development of learning media, based on augmented reality to support quick learning consists of 3 (three) significant steps, namely preliminary studies, product development, and testing as seen in Figure 1 (Dekdouk, 2012). This research conducted in the Department of Computer Science Education, Faculty of Mathematics and Natural Sciences Education, Universitas Pendidikan Indonesia.

The research steps are as follows:

2.1 Preliminary Study

At this stage set the goal of software development, both for students, teachers, and the environment. For this purpose, the analysis is done in cooperation with the teacher and still refers to the curriculum used. In addition to the objective analysis, analysis of software development needs is also required. Needs analysis is the first stage that becomes the basis of the next software development process. The smoothness of the entire software creation process and the completeness of the resulting software features are highly dependent on the results of this needs analysis. To obtain information about the needs in making this interactive learning media, researchers through explorative studies and literature study (Azuma, 1997).

2.2 Developing

This stage includes the determination of the elements that need to be loaded in the multimedia learning that will be developed based on the design of learning or often referred to as the ID model (Instructional Design). The results of this stage include a storyboard (storyboard), which is how this multimedia is displayed (interfacing). How to present materials, 3D models for learning, animation, evaluation, and more. Also, the result of this step is the interactive multimedia learning system flowchart from start to program until the end of the plan (Ardhianto, Hadikurniawati, Winarno, 2012; Kemp & Dayton, 2003).

This stage is the stage of multimedia learning development based on a storyboard that has been made, making multimedia such as 3D model and animation until evaluation, storyline creation, integration among all these aspects, and program design. After that, judgment is made to the expert. This assessment covers the assessment of interfaces, text, 3D models, interactivity and the content of learning (Ardhianto, Hadikurniawati, & Winarno, 2012, Kemp & Dayton, 2003).

2.3 Assessment Stage

To measure the results of the expert judgment, the Scale Rating scale is used. Rating Scale or scale is a subjective measure made scale (Kemp & Dayton, 2003). The rating scale is not limited to the measurement of attitudes alone, but to measure respondents' perceptions of other phenomena, such as scales for socioeconomic status, institutional status, knowledge, skills, the process of activities and others (Kemp & Dayton, 2003).

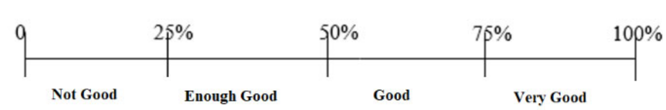

Figure 2 The criterion score

Figure 3 MatSemat card model

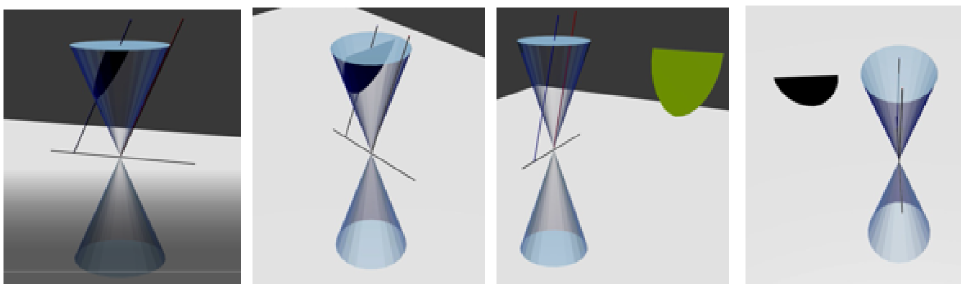

Figure 4 Illustration of cone slice

Regarding aspects assessed at the expert validation stage, the adaptation of the multimedia learning development criteria. These Aspects are Common Aspects, Aspects of Media, Aspects of Learning, and Visual Communication Aspects (Cawood, Fiala, & Steinberg, 2007).

The data that has been collected in the validation questionnaire is qualitative data because each statement item is divided into a very bad, bad, useful, and excellent category. To calculate the data first into quantitative data by the weight of the score of one, two, three, and four. After the data is transformed, then the calculation of the rating scale can be done with the following formula (Azuma, 1997).

$$P = \frac{actual\ score}{ideal\ score} \times 100\%$$

Note:
P = Percentage

The interpretation scale is made by dividing the criterion score into four continua then the continuum result is made as the following categories in Figure 2 (Azuma, 1997). Qualitative data, such as comments and suggestions, serve as a basis for revising interactive multimedia learning.

3. RESULT AND DISCUSSION

3.1 Multimedia Products

The resulting multimedia is -based augmented reality for learning conic sections consisting of circular, parabolic, elliptical, and hyperbola materials. Learning tools consist of material books, object cards, and a camera or mobile phone. The map includes all the image objects present in the book for ease of use and is named MatSemat as a Mathematic Smart extension. The image code is adjusted between the paper and the card based on the material affairs set out in the book. Figure 3 and 4 is an example of augmented based multimedia card (Santoso & Gook, 2012; Geroimenko, 2012). The front page of the card contains the logo of Universitas Pendidikan Indonesia; the back includes an image of the object, the number of the picture according to the book, the name of the drawing, and the short description.

3.2 Products Judgment by Experts and Users

3.2.1 Multimedia Aspect Judgment

Using 3 (three) essential parameters of an electronic media, namely general aspects, software engineering, and visual communication, media experts provide an assessment as in Table 1. From Table 1. it can be shown, according to media experts that the multimedia developed has an outstanding category and in a contingent basis with average feasibility of 87.61% which is categorized very high and in the continuum as shown in Figure 5.

Table 1 Assessment of media aspect

Aspec	Sum Expert	Sum Comp.	Ideal Score	Actua l Score	%
G	2	3	30	26	86.67
SE	2	9	90	80	88.89
VC	2	11	110	96	87.27
Average					87.61

Note:
G: General; SE: Software Enginnering; VC: Visual Communication

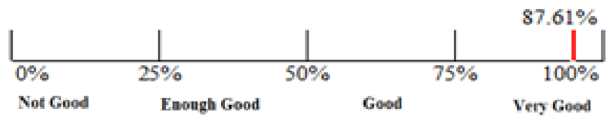

Figure 5 Critical scale assessment of media experts

Multimedia-based augmented reality generated is declared appropriate for use in learning circles, parabola, ellipses, and hyperbole. Multimedia produced contributes to learning, including the following (Kemp and Dayton, 2003). (1) Submission of learning messages can be more standardized. (2) Learning can be more enjoyable. (3) Learning becomes more interactive by applying learning theory. (4) The time for implementing learning can be shortened. (5) Quality of learning can be improved. (6) The learning process can take place whenever and wherever needed. (7) The positive attitude of students towards learning materials and the learning process can be improved. (8) The role of the teacher experiences changes in a positive direction.

3.2.2 Content Aspect Judgment

Assessment of material aspects uses 3 (three) essential parameters of an electronic media, namely general elements, content subject; and learning. Material experts provide an assessment, as stated in Table 2. From Table 2., it can be shown that the multimedia assessment by material experts found an average percentage of the feasibility of 87.22%, which is categorized very high and in contour, as shown in Figure 6.

Multimedia-based augmented reality generated was declared feasible by material experts for use in learning circles, parabola, ellipses, and hyperbole. Material aspects show feasibility above average, while the other two points are below average. This indicates that multimedia based on augmented reality can extract material richer, more varied, detailed, and dynamic. Such dynamic learning media are by the characteristics of students as some millennia, including fun, multitasking, and random access (Trilling & Fadel, 2009).

Table 2 Assessment of ascpect matter

Aspect	Num Expert	Num Comp.	Ideal Score	Actual Score	Quality (%)
G	2	3	30	26	86.67
CS	2	4	40	34	85,00
L	2	12	120	108	90,00
Average					87.22

Note:
G: General; CS: Content Subject; L: Learning

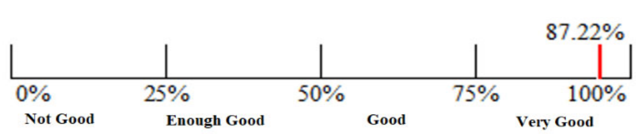

Figure 6 Critical scale material assessment

Table 3 User Assessment

No.	Aspect	Quality (%)
1	Navigation key in multimedia	80,00
2	Multimedia View	83,36
3	Ease of Use Multimedia	83,33
4	Multimedia Interactivity	8 0,00
	Average	81,67

Figure 7 User critical scale

3.2.3 Assessment By Users

User assessment is an operational aspect of multimedia that is more precisely testimony. The operational element uses 4 (four) essential parameters of an electronic media, namely completeness, and clarity of flow, compatibility/suitability of appearance, ease of operation, and interconnection, interactivity. The users provide an assessment, as stated in Table 3. From Table 3, it can be shown that according to prospective users, the average percentage of feasibility is 81.67%, which is categorized very high, and on a continuum, as shown in Figure 7.

Multimedia-based augmented reality generated is expressed according to operational standards and is appropriate for users to use in learning circles, ellipses, parabola, and hyperbole. Navigation and interactivity aspects are below average, while the appearance and convenience are above average. In this context, prospective users, namely students, pay more attention to the presentation, and ease of operation. Assessment of potential users is lower than media experts. This shows that the millennial generation has been waiting to interact with the media like that, especially those that smell like games that feature appearance (Trilling & Fadel, 2009).

Table 4 Target test

No.	Results
1	Tracking works well, but the distance between the camera and the marker is not too close.
2	The display looks ideal on the tracking process with a viewing angle of 45o, and the target is seen entirely.
3	The target looks too small with a 60^o viewpoint, and in this case, the tracking process works long enough.
4	The target looks too small, with a 70^o point of view, and in this case, the tracking process cannot work.

Table 5 Distance test

Elevation	Dintance (Cm)
0	10, 15, 25, 50
30	10, 15, 50
45	10, 15, 25, 50

3.3 Multimedia Visibility

To determine media visibility, black box testing is carried out by looking at the input, treatment, response, sensitivity, output, or event changes. For this reason, alpha and beta testing techniques are used.

3.3.1 Alpha Testing

Alpha testing is done to see the initial condition of the media. The initial term of the media is the reading or introduction of marker objects by the camera until the final output of the object. The following are the results of testing the target object, as shown in Table 4. The next test is the distance between the camera and marker, the reflection of light and the success of the camera's tilt angle at a minimum illumination of bright lights or cloudy sunlight and the results are read well at some angles of distance funds as seen in Table 5. The alpha test results show the success of excellent and visible viewing of augmented reality objects. With bright levels of natural sunlight, augmented objects can be observed. The tilt angle 0^o-45^o is a standard limit for smartphone users, as well as a distance of 10-50 cm is an average distance that is naturally done or occurs (Geroimenko, 2012). The following are the results of the multimedia product journey test as to where Tables 6, 7, 8, and 9. The module starts running successfully, which is the initial gateway that checks all the readiness of multimedia devices to run (Geroimenko, 2012). The control module runs successfully, which is a guarantee of the running of the rules that have been set according to the set and expected flow (Geroimenko, 2012). The instruction module runs successfully, which is a guarantee of the running of the rules that have been set according to the predetermined and expected path (Geroimenko, 2012). The exit module works successfully, which is the finalization of the process of running the media. The output module creates an aggregate or dashboard of all processes that have been run electronically (Geroimenko, 2012).

Table 6 Starting menu test

Input	Expected	Observation	Conclusion
Click the "Star" menu	Displays notification information whether you want to leave the media or not	Displays a confirmation notification	Accepted

Table 7 Control test

Input	Expected	Observation	Conclusion
Click the "Control" menu	Displays notification information whether you want to leave the media or not	Displays a confirmation notification	Accepted

Table 8 Navigation test

Input	Expected	Observation	Conclusion
Click the "Help" menu	View information and how to play objects	Show game instructions	Shown

Table 9 Quit test

Input	Expected	Observation	Conclusion
Click the "Exit" menu	Display notification information whether to get out of media or not	Displays a confirmation notification	Accepted

3.3.2 Beta Testing

The beta test is the level of use or use of multimedia by the user which includes aspects of navigation, attraction, satisfaction, and perceived or acquired impacts as shown in Tables 10, 11, 12, 13, 14, and 15. In general, 87% of users stated that they were used to dynamic media, and only 13% said they were unfamiliar or familiar. The users mostly understand the flow that occurs in running a progressive media (Santoso & Gook, 2012). In general, 100% of users state that dynamic media is enjoyable to use in learning. All users agree that media augmented reality makes it happy in its implementation and matches the fun character of the millennial generation (Santoso & Gook, 2012). In general, 87% of users expressed satisfaction with dynamic media, and only 13% said they were less or dissatisfied. There are still things that need to be improved, especially the availability of existing or owned infrastructure (Geroimenko, V. 2012). In general, 100% of users say there are no difficulties and are accustomed to running dynamic media, and no users have trouble. This is in line with the digital age and users as millennials (Geroimenko, V. 2012). In general, 100% stated that they understood the material thoroughly from dynamic media, and no one indicated that they did not understand. Content that is presented

Table 10 Navigation test

Answer	Percentage (%)
Very helpful	27%
Help	60%
Doubt	13%

Table 11 Level of interest

Answer	Percentage (%)
Interested	53%
Doubtful	13%
Not Interested	0%

Table 12 Level of satisfaction

Answer	Percentage (%)
Very helpful	27%
Help	60%
Doubt	13%

Table 13 Level of convenience

Answer	Percentage (%)
Easy	83%
Ordinary	17%
Difficult	0%

Table 14 Level of material understanding

Answer	Percentage (%)
Yes	93%
Doubt	7%
No	0%

Table 15 Level of interest/motivation

Answer	Percentage (%)
Yes	57%
Doubt	30%
No	13%

dynamically is more acceptable and appreciated because it is easier to abstract in the minds of users or students (Geroimenko, V. 2012). In general, 87% of users stated that magnetic media motivated them, and only 13% said it was mediocre. Augmented reality media can increase learning motivation of most users (Geroimenko, V. 2012).

4. CONCLUSION

This study produced a multimedia learning model of mathematical material for circles, ellipses, parabola, and hyperbole based on augmented reality. Some things that can be concluded from this research activity are: *first,* As smart-based technology, smart content is needed to support quick learning. *Second*, multimedia-based augmented reality is part of smart content capable of making learning more dynamic. *Third*, multimedia-based augmented the reality of mathematical material for circles, ellipses, parabola, and hyperbole according to the standards of electronic media and dynamic learning. *Fourth,* multimedia-based augmented the reality of mathematical material for circles, ellipses, parabola, and hyperbole according to the character of millennial generations. *Fifth,* multimedia-based augmented reality of mathematical material for circles, ellipses, parabola, and hyperbole are generally attractive, easy to operate, facilitate understanding, increase motivation, and challenge.

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