



The Development of Android-based Augmented Reality Learning Media in Curved Surfaces Geometry

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Submitted: 23-12-2023

Revised: 10-06-2024

Accepted: 15-06-2024

Published: 30-06-2024

ABSTRACT

The increasing level of technology used in the education sector has an impact on the use of technology as a learning media. The research aims to develop and produce an android-based augmented reality learning media in curved surfaces geometry for junior high school students and to know student's respond to the learning media. The type of this research is research and development and used the Luther-Sutopo Multimedia Development Method. Six stages to develop the android-based augmented reality learning media in geometry are concept, design, material collecting, assembly, testing and distribution. In the fifth stage, testing, the learning media tested at two steps, by validators and student's respond. The validators gave score as much as 85.95% (valid without revision) for the content and construct materials of the learning media. The students gave good response of learning media, it can be seen from in the usefulness aspect, 70% of respondents agreed that this learning media was useful and could be used in the learning process of curved geometric shapes. For the ease of use aspect 55% of respondents agreed that this learning media was easy to use. For the ease of learning aspect 50% of respondents agreed that this learning media could help them in the process of understanding curved surfaces geometry material and for the satisfaction aspect 65% of respondents felt learning geometry with the help of learning media was fun and would recommend using this learning media to their friends.

Keywords: android-based learning media; augmented reality; geometry; students' responses

INTRODUCTION

Information and communication technology plays a very important role in the learning process. National Council of Teachers of Mathematics stated that technology is an essential tool for learning mathematics in the 21st century, and all schools must ensure that all their students have access to technology. Effective teachers maximize the potential of technology to develop students' understanding, stimulate their interest, and increase their proficiency in mathematics. When technology is used strategically, it can provide access to mathematics for all students (NCTM, 2000). One of the important ideas of the NCTM statement above is that effective teachers are expected to be able to exploit the potential of technology to develop student understanding, stimulate interest in learning, and improve students' mathematical skills. Based on this statement, it is known that one of the roles of technology in learning mathematics is a tool for the development and understanding of concepts. One of the examples is the technology-based mathematics learning media.

Learning media has an important function in learning. Through learning media, teachers can present teaching material clearly and are not verbalize so students can think concretely and clearly. Unfortunately, the use of technology as a media of learning is still lack at this time in Indonesia. This is in line with the research of *Badan Pusat Statistik*

Indonesia titled *Use and Utilization of Information and Communication Technology (P2TIK) in Education Sector 2018* stated that the proportion of schools that use of technology such as in teaching and learning activities is 21.32%, while the proportion of schools that use technology such as radio in teaching and learning activities is 19.08% (BPS-Statistik, 2018). In fact, according to BPS, the use of smartphones at the age of teenagers to adults is very capable, both in North Sumatra and in other regions. In addition, the availability of the internet has also been evenly distributed in various regions. Therefore, there is a need for better use of technology, especially in the education sector.

One of the topics which learn at school is mathematics. Mathematics exists in various fields in life. Mathematics becomes the basis and aids for other sciences, for example, biology, chemistry, and physics. Nevertheless, many students think that mathematics is difficult to understand, so students' perception emerges that mathematics is difficult. There are many children after learning mathematics in a simple part, do not understand it, and many concepts are misunderstood. Mathematics is considered a difficult and deceptive science (Russefendi, 2006). Some constraints that form these perceptions are the abstract mathematical characteristics, media problems, students or teacher problems.

The object of mathematics is abstract. Mathematics contains objects which are unique to itself (Mitchemore & White, 2004). One of the important topics in mathematics is Geometry. Geometry is one of the fields in mathematics that studies points, lines, field and space as well as the properties, measurements, and the relation of one to another. Geometry is one of the main components in the mathematics education curriculum throughout the world (Dindyal, 2007). NCTM (National Council of Teachers of Mathematics) explains the reasons why geometry needs to be taught in schools, are: (1) because the world is built by shapes and spaces, according to Bishop's opinion (1983) that geometry is space mathematics, (2) formal geometry is very helpful for students who facing the problem of abstraction, (3) helps solve problems in other fields of mathematics, (4) helps to increase students visual thinking ability.

Geometry is one of the materials in mathematics that studies abstract objects, so the cognitive stage of students is not perfectly able to understand these objects. Even though understanding the concepts and objects in geometry is a fundamental thing that must be done by a student. This is in line with Piaget. Piaget introduced four stages of cognitive development that determined reasoning and mental development skills of a person from his childhood to adulthood. In particular, ages 11-14 years old (8th grade students) as an age in which a transition occurs in their cognitive development from stage of concrete operational to formal operational. Meanwhile, relating to cognitive development, many junior high school students have not yet acquired the ability to understand abstract concepts without a real basis (Kusmaryono, Suyitno, et. al., 2018)

In reality, the geometry ability of junior high school students in Indonesia are still relatively low. This can be seen from the result of research conducted by Nursyam (2012), it was found that the geometry comprehension of junior high school in Indonesia is still low. Moreover, Khusnul Safrina, et al (2018) stated that the reality shows that there are still many students who have difficulty in studying geometry material. One of the difficulties faced by students when learning geometry is the difficulties in visualizing three-dimensional material (Putri, Wahyuningsih, et.al., 2023). In line with that, based on

the results of PISA research conducted by the Organization for Economic Cooperation and Development (OECD) in 2018 concluded that the mathematical literacy ability of junior high school students in Indonesia was still low (decreased from the previous period), where Indonesia obtained an average score of 379 while the average international mathematical literacy was 487. PISA results in the mathematics literacy study of Indonesian students have not yet reached the PISA standard.

Therefore, one of the things that can help students to understand geometric objects, especially curved side shapes is to provide learning media that allows students to study these objects in a more concrete way and help students to visualize 3-dimensional objects easier. One of the learning media that can be used is learning media based on augmented reality. Augmented Reality (AR) technology is a technology that combines virtual information with the real world (Sirakaya & Sirakaya, 2018); (Avilia-Garzon & et al., 2021). AR has attracted a lot of interest in the research community because it provides unique learning experiences that cannot be achieved using other technologies or approaches. Augmented Reality can be applied for learning, entertainment, or edutainment by enhancing a user's perception of and interaction with the real world (Kesim & Ozarslan, 2012).

Previous research used augmented reality to make it easier for students to learn flat surface geometry (Nevarini, et.al., 2023). Apart from that, there is also research that discusses the use of augmented reality to study the material of curved surfaces geometry along with the surface area and volume of these shapes. In this research, several learning media developments were developed so that students could find ways to calculate the surface area of three-dimensional shapes independently. Students can access this in this learning media which displays videos related to this matter.

Based on this background, the researcher conducted research entitled “The Development of Android-based Augmented Reality Learning Media in Curved Surfaces Geometry”.

RESEARCH METHOD

The type of this research is research and development. According to (Borg & Gall, 1983), educational research and development is a process used to develop and validate educational products. This research called research and development because this research will produce a new product in the form of android-based augmented reality learning media in geometry. This research used the Luther-Sutopo Multimedia Development Method.

In this research, the respondents are grade IX students at one of the secondary schools in Medan, Sumatera Utara who learned geometric curved surfaces topic. The object of this research is android-based augmented reality learning media in geometry that already developed by the researcher and validated by experts. Furthermore, the researcher used a questionnaire developed by Lund (2001) namely USE (usefulness, satisfaction, and ease of use) student response questionnaire. Data was collected by using a questionnaire. Through the answers of the questionnaire and the result of the interview, the researcher will describe how students respond to the augmented–reality learning media on students’ learning process.

RESULT AND DISCUSSION

The Development of the Learning Media

This research produced the android-based augmented reality learning media. The content of the learning media discussed the 3-dimensional figure spaces with curved surfaces. This learning media is made for junior high school students who learn the topic. The learning media allows students to augment their reality about the 3-dimensional figure spaces with curved surfaces. The development of the learning media used Blender 3D 2.8, Unity 2019.4.16f1, Vuforia, and Canva. The development method used the Luther-Sutopo Multimedia Development Method. The steps of the development method are described below:

1. Concept

This stage is the initial and fundamental step of the learning media development. The purposes of the learning media are to provide the suitable learning media in 3-dimensional figure spaces with curved surfaces (cylinder, cone and sphere) which can help student visualize the 3-dimensional object and understand about the surface area and the volume of these object and to provide new and interesting learning experience for students. The user target of this learning media is student who learn about 3- dimensional figure spaces with curved surfaces (student grade IX in Secondary School).

2. Design

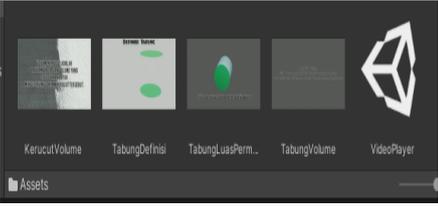
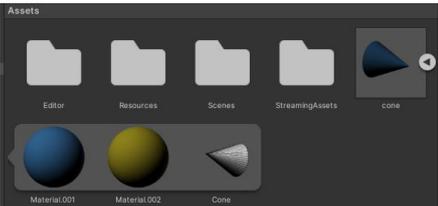
After compiling the concept of the learning media, the next step which is the design will be done. The output of this step are the video animation, 3D figure spaces with curved surfaces, and book design that contain the marker of the augmented reality.

3. Material Collecting

This stage aims to collect the content material which is determined at the design stage. In this stage, the video animation is produced from the *Blender* application.

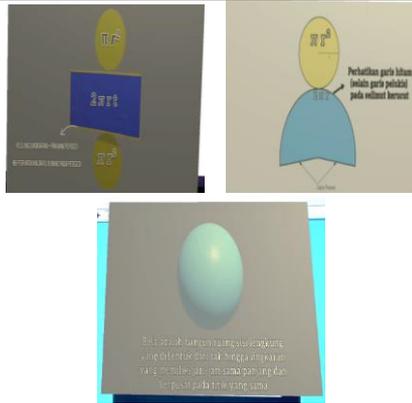
4. Assembly

This stage aims to assemble all of the content material to develop the learning media. To do this step, the researcher used Unity 2019.4.16f1 and Vuforia. After all the learning media content designs are ready, the assembly stage begins using the Unity and Vuforia applications. The following is a story board for the development of learning media

No	Display	Information
1		Using the help of the Unity Hub application to create an augmented reality-based learning media application. At this stage, all designs of learning media content will be built into an application
2		Using the Vuforia Engine and AR Camera applications to create augmented reality-based learning media. The application will be automatically built. This learning media can be downloaded at the following link https://bit.ly/3iNzIEl

Display Of Learning Media Applications

3



In the developed augmented reality-based learning media, there is a simple explanation regarding the volume and surface area of each three dimensional shape. Apart from that, it also shows the nets of each of them.

5. Testing

This step is carried out by two experts/ validators. The testing was divided into two categories, namely content and construct validity. In content validity, the researcher assessed the suitability of the subject matter with the basic competence, the accuracy of the subject matter, an update of the subject matter, the technique to presenting the subject matter, straightforward, and the suitability to students (user). The average score for content validity is 84,4% (from two experts) means the learning media can be used with a little improvement. While, in construct validity, the researcher assessed the ability of the learning media to present the subject matter, communicative, technique to presenting subject matter in the learning media. The average score for the construct validity is 87,5% (from two experts) means the learning media can be used with a little improvement.

After the improvement, this learning media can be said as a valid learning media which is a learning media that is material based on state-of-the-art knowledge (content validity) and all components are consistently linked to each other (construct validity).

6. Distribution

This stage aims to distribute the learning media to the research location so that the learning media can be used in the learning process by the teacher.

Students' Questionnaire

There are twenty students who participated in this test and there are 30 questions. The questionnaire has four parts of question, there are usefulness (8 questions), ease of use (11 questions), ease of learning (4 questions) and satisfaction (7 questions). Below are the results of student's questionnaire each part of question:

Usefulness

This aspect of the questionnaire is intended to find out whether the learning media used is useful and can be utilized optimally. To find out this, several indicators have been compiled as follows:

Table 1. Indicator of Usefulness Aspect

Aspect	Indicator
Usefulness	The learning media helps me to be more effective in understanding 3-dimensional shape with curved side
	The learning media helps me to be more productive when I am learning about 3-dimensional shape with curved side
	The learning media is useful to use
	This learning media is giving big impact in my learning process
	This learning media was helping me to find the solution of the 3-dimensional shape with curved side problems
	This learning media was helping me to save my time to learn and understand about 3-dimensional shape with curved side
	This learning media is suitable with my needs
	This learning media is suitable with my expectation

Then do the calculation of each indicator using a Likert scale. After that, the conversion of the assessment scores was carried out into several categories. The following is a score conversion table for the student opinion questionnaire:

Table 2. Conversion of Average Score Scale of Usefulness Aspects

Interval Score	Category
$X < 28$	Not Feasible
$28 \leq X < 33$	Fairly feasible
$X \geq 33$	Feasible

After converting the scores into categories, it was found that 70% of respondents agreed that this learning media was useful and could be used in the learning process of curved geometric shapes. While 20% of other students feel quite useful from this learning media and 10% of other respondents feel that this learning media has not helped them enough in learning the geometry of curved side shapes.

Ease of Use

This aspect of the questionnaire is intended to determine the ease of use of learning media. To find this out, several indicators have been compiled as follows:

Table 3. Indicator of Ease-of-Use Aspect

Aspect	Indicator
Ease of Use	This learning media is easy to use
	The procedure of the learning media is simple to uses
	This learning media is easy to understand (user friendly)
	This learning media require a few steps possible to accomplish what I want to do with it
	This learning media is flexible
	I do not meet any difficulties when using the learning media
	I may use this learning media without written instruction
	I don't notice any inconsistencies as I use it.
Both occasional and regular users would like it	

I can recover from mistakes quickly and easily
 I can use it successfully every time

Then do the calculation of each indicator using a Likert scale. After that, the conversion of the assessment score into several categories is carried out, as follows:

Table 4. Conversion of Average Score Scale of Ease of Use Aspects

Interval Score	Category
$X < 43.7$	Not Feasible
$43.7 \leq X < 49.3$	Fairly feasible
$X \geq 49.3$	Feasible

After converting scores into categories, it was found that 55% of respondents agreed that this learning media was easy to use. While 25% of other students feel that this learning media is quite easy to use and 20% of other respondents still experience difficulties when using this learning media.

Ease of Learning

This aspect of the questionnaire is intended to find out whether this learning media can be used easily in the learning process so that students can understand the material more easily. To find this out, several indicators have been compiled as follows:

Table 5. Indicator of Ease of Learning Aspect

Aspect	Indicator
Ease of Learning	I learned to use it quickly
	I easily remember how to use it
	It is easy to learn how to use it
	I quickly became skillful with it

Then do the calculation of each indicator using a Likert scale. After that, the conversion of the assessment score into several categories is carried out, as follows:

Tabel 6. Conversion of Average Score Scale of Ease of Learning Aspects

Interval Score	Category
$X < 16.67$	Not Feasible
$16.67 \leq X < 18.33$	Fairly feasible
$X \geq 18.33$	Feasible

After converting scores into categories, it was found that 50% of respondents agreed that this learning media could help them in the process of understanding geometric material on curved side shapes. Furthermore, another 20% of respondents were quite helped when learning geometry with learning media, while 30% of other students still found it difficult during the learning process even with the help of these learning media.

Satisfaction

This aspect of the questionnaire is intended to determine student satisfaction when using this learning media, in addition to this aspect students' learning experiences are also

assessed when using learning media. To find this out, several indicators have been compiled as follows:

Table 7. Indicator of Satisfaction Aspect

Aspect	Indicator
Satisfaction	I am satisfied with it
	I would recommend it to a friend
	It is fun to use
	It works the way I want it to work
	It is wonderful
	I must have it
	It is pleasant to use

Then do the calculation of each indicator using a Likert scale. After that, the conversion of the assessment score into several categories is carried out, as follows:

Table 8. Conversion of Average Score Scale of Satisfaction Aspects

Interval Score	Category
$X < 27.4$	Not Feasible
$27.4 \leq X < 28.6$	Fairly feasible
$X \geq 28.6$	Feasible

After converting scores into categories, it was found that 65% of respondents felt learning geometry with the help of learning media was fun and would recommend using this learning media to their friends. 25% of respondents felt that this learning media was not fun and they did not enjoy the learning process with the help of this media and another 10% felt it was just ordinary.

From the response of the student questionnaire can be concluded that most of the students gave variety respond in the questionnaire. This is also in accordance with the reasons why they gave the response. Most of the student's said that they are helped with this media, while using this media they are easier to understand the 3-dimentional figure space with curved surfaces because of the animation, the way the material presented, the language used (understandable) and easy to use. However, some students said that they found out the problem when going to download the app. In researcher opinion this problem occurred because of the connection of the internet or the qualified of the android smartphone.

Because the student response was quite positive, it can be concluded that the use of augmented reality learning media can help students understand abstract mathematical objects and is able to provide a fun place to learn mathematics, so that it can be considered by future researchers to develop various learning media that can help students understand mathematics.

Based on these findings, it was identified that android-based augmented reality learning media can improve student interest in curved surfaces geometry. In line with this, previous research states that the learning process becomes more enjoyable for students when learning with augmented reality learning media (Nevarini et.al., 2023). Besides that, another research said the implementation of augmented reality in learning process made

students enthusiastic about participating in learning and arouse student curiosity (Setyawan et al., 2019).

CONCLUSION

The development of android-based augmented reality learning media in geometry for junior high school can be done with using the Luther-Sutopo method. This research development method has six stages, there are concept, design, material collecting, assembly, testing, and distribution. This learning media has been validated by the validator/expert and got an average percentage score of as much as 85.95% which means the learning media is valid without revision. The response of students about this learning media is very good. This can be seen from the results of the questionnaire. For the usefulness aspect, 70% of respondents agreed that this learning media was useful and could be used in the learning process of curved geometric shapes. For the ease-of-use aspect, 55% of respondents agreed that this learning media was easy to use. For the ease of learning aspect, 50% of respondents agreed that this learning media could help them in the process of understanding geometric material on curved side shapes, and for the satisfaction aspect 65% of respondents felt learning geometry with the help of learning media was fun and would recommend using this learning media to their friends.

REFERENCES

- Avilia-Garzon, C., & et al. (2021). *Augmented Reality in Education: An Overview of Twenty-Five Years of Research*. Contemporary Educational Technology, 13(3), 1-29. <https://doi.org/10.30935/cedtech/10865>
- Borg, W. R., & Gall, M. (1983). *Educational Research: An Introduction, 4th edition*. London: Longman, Inc.
- Dindyal, J. (2007). High School Students use of patterns and generalisations. *Proceedings of the 30th Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 236-245). Australia: Research Grup Australia.
- Indonesia, B.-S. (2018). *Use and Utilization of Information and Communication Technology (P2TIK) in Education Sector*. Indonesia: Badan Pusat Statistik.
- Kesim, M., & Ozarslan, Y. (2012). Augmented reality in education: current technologies and the potential for education. *Social and Behavioral Sciences*, 47(1), 297-302. <https://doi.org/10.1016/j.sbspro.2012.06.654>
- Kusmaryono, I., Suyitno, H., & et. al. (2018). Analysis Of Abstract Reasoning From Grade 8 Students In Mathematical Problem Solving With Solo Taxonomy Guide. *Infinity: Journal of Mathematics Education*, 7(2), 69-82. <https://doi.org/10.22460/infinity.v7i2.p69-82>
- Lund, A. M. (2001). Measuring usability with the use questionnaire. *Usability interface*, 8(2), 3-6.
- Mitchemore, M., & White, P. (2004). Abstraction In Mathematics And Mathematics Learning. *The 28th Conference of the International Group for the Psychology of Mathematics Education* 3(22), 329-336. Sydney: ACU
- NCTM. (2000). *Principles and Standards for School Mathematic*. Reston, VA: NCTM.
- Nevarini, M., Agustiani, R., & Zahra, A. (2023). Application of Augmented Reality in Geometry Learning in Increasing Student Learning Motivation. *Journal of Curriculum*

- and Pedagogic Studies (JCPS)*, 2(1), 40-50. <https://e-journal.lp2m.uinjambi.ac.id/ojp/index.php/jcps>
- Putri, A., Wahyuningsih, T., Ananti, N. S., Wicaksono, A., Gharitza, Z. S., As'ari, A. R., ... & Osman, S. (2023). EUCLIDA: 3D Augmented Reality Card for Learning Numeracy about Geometry. *TEM Journal*, 12(2), 1174. <https://doi.org/10.18421/TEM122-63>
- Ruseffendi, E. T. (2006). Pengantar kepada membantu guru mengembangkan kompetensinya dalam pengajaran matematika. *Bandung: Tarsito*.
- Setyawan, B., & Fatirul, A. N. (2019). Augmented reality dalam pembelajaran IPA bagi siswa SD. *Kwangsan*, 7(1), 286912. <http://dx.doi.org/10.31800/jtp.kw.v7n1.p78--90>
- Sirakaya, M., & Sirakaya, D. A. (2018). Trends in Educational Augmented Reality Studies: A Systematic Review. *Malaysian Online Journal of Educational Technology*, 6(2), 60-75. <http://dx.doi.org/10.17220/mojet.2018.04.005>